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CONTENTS

Siliceous Sponge Spicules of Pennsylvanian Age from Illinois and Indiana — *J. Marvin Weller* 233

The Cretaceous Section of Maverick County, Texas — *H. C. Vanderpool* 252

Age of the Kreyenhagen Shale in the Cantua Creek—Panoche Creek District, California — *D. Dale Condit* 259

The Genus *Bolivinella* in the Oligocene of Mississippi — *Henry V. Howe* 263

The Genus *Orbitoides* in America, with Description of a New Species from Cuba — *Donald W. Gravell* 268

Eocene Foraminifera from Mexico — *W. L. F. Nuttall* 271

PALEONTOLOGICAL NOTES

Jonesites, a New Name for the Ostracode Genus *Placentula* — *H. N. Coryell* 294

The Dates of Publication of Tempère and Peragallo's *Diatomées du Monde Entier*, Edition 2 — *G. D. Hanna* 296

The Ostracode Genus *Hollinella* — *Charles H. Blake* 297

METHODS AND TECHNIQUE

The Preparation of Paleontologic Illustrations — *John B. Reeside, jr.* 299

REVIEWS AND NEW PUBLICATIONS

B. Brashad,—Recent and Fossil Viviparidae — *Junius Henderson* 309

L. S. Russell,—Upper Cretaceous and Lower Tertiary Gastropoda from Alberta — *Junius Henderson* 310

SOCIETY RECORDS AND ACTIVITIES 311

AMONG PALEONTOLOGISTS 313

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SEPTEMBER 1930

SILICEOUS SPONGE SPICULES OF PENNSYLVANIAN AGE FROM ILLINOIS AND INDIANA[1]

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ABSTRACT

Spicules of six genera and twelve species of siliceous sponges, and of one genus and species of calcareous sponges are described from Lower Pennsylvanian beds of Illinois and Indiana. A new genus of hexactinellid sponges called *Rhakistellia* is proposed. All but two of the species described are new.

Sponges capable of fossilization under ordinary circumstances possess a true skeleton composed of spicular elements secreted by the animal itself. These spicules are composed of either a hydrated form of amorphous silica allied to opal, or calcite, in each case with a slight admixture of organic matter. Most of the fossil sponges which have been described from American strata of Paleozoic age are forms in which the spicules are joined to form a rigid framework or cemented together into a series of anastomosing fibers. The skeletons of such types have commonly not become disintegrated after the death and decomposition of the animals that formed them and consequently have been preserved as fossils in a more or less complete condition.

Other sponges which occur equally, if not even more abundantly, possess numerous unconnected siliceous spicules bound together into a flexible skeleton by an organic substance known as *spongin*. This material readily decomposes after the death of the sponge and the spicules are loosened and scattered upon the sea bottom. Fossil remains of such sponges other than the isolated spicules are rare.

It has long been known that a large part of the silica composing cherts in the Paleozoic limestones was derived from the remains of

[1]Published by permission of the Chief, Illinois State Geological Survey.

sponges. Apparently, however, the skeletons of these organisms are unusually subject to attack and alteration by ground water so that few localities are known when they are well preserved. The minute structure of those sponges which possessed rigid skeletons is very rarely preserved. In most cases it is necessary to classify them on the basis of external form and in many cases it is not known with certainty whether their skeletons were originally calcareous or siliceous. The minuteness of the skeletal elements of those sponges which possessed unconnected siliceous spicules has rendered them inconspicuous and their presence has been commonly overlooked. The classification of these forms also is attended with great uncertainty as peculiarities in form and shape of isolated spicules are the sole features upon which it can be based.

The only notice of siliceous sponge spicules of Pennsylvanian age in America was published by Ulrich[2] who proposed names for one new genus and two new species on the basis of material collected from the limestone cap-rock of the Rock Island (No. 1) coal at Seville, Fulton County, Illinois.

The spicules described below were obtained from the limestone cap-rock of the Rock Island (No. 1) coal exposed in the southwest corner of Sec. 25, T. 17 N., R. 1 W., Rock Island County, Illinois, and from a limestone occurring low in the Pennsylvanian section and cropping out along Redwood Creek near the center of the N. ½ Sec. 35, T. 21 N., R. 9 W., Warren County, Indiana. The limestones at both of these localities are dense, dark colored and impure. The occurrence of silicified fossils such as bryozoa and small gastropods at these places attracted particular attention and the sponge spicules were discovered in the insoluble residues obtained by treating fragments of the rock with hydrochloric acid. It is probable that the silica which has replaced the calcium carbonate of the other fossils was derived from sponge spicules but silification is very unequally developed. The sponge spicules have been obtained only from those portions of the rock which also contain other fossils in a silicified condition.

Associated with the limestone cap-rock of the Rock Island (No. 1) coal at numerous localities in Rock Island and Mercer counties a bed of dark colored chert occurs in one or more layers. This has been observed, however, only at those places where the unconformity beneath the overlying sandstone has cut downward to the limestone cap-rock. At such places the chert occurs immediately beneath the sandstone and rises or falls following the irregularity of the unconformity. Because the

[2]E. O. Ulrich, "Devonian and Carboniferous Sponges," *Illinois Geol. Survey*, Vol. 8 (1890), pp. 245-251.

chert parallels the unconformity in this manner and has no apparent relationship with the bedding of the limestone it was at first concluded that the material which was altered to produce the chert was deposited subsequent to the erosion that resulted in the unconformity. Microscopic examination of thin sections, however, reveals the presence of abundant but somewhat obscured sponge spicules in the chert. It is evident, therefore, that this material was produced by alteration of the upper surface of the limestone either when it was exposed to weathering after erosion had brought it to the surface or by ground waters which circulated more or less freely in the overlying sandstone at some later time.

The original amorphous condition of the silica of which the spicules from both the Illinois and Indiana localities were composed has been altered to a mass of tiny quartz crystals showing distinct birefringence in polarized light with crossed nicols. The axial canals of many of the specimens obtained from Rock Island County, Illinois, have been greatly enlarged and the spicules are generally preserved as thin siliceous shells. The axial canals of those from Warren County, Indiana, however, have been largely obliterated and they now occur as solid bodies which only show faint suggestions of the original tiny central perforation toward the tips of some of the rays in a few specimens.

These sponge spicules are of interest on account of their comparatively large size and robust form which is exceeded by few Carboniferous spicules known from other parts of the world. No spicules comparable to the smaller types which are present in the bodies of most modern sponges have been found. It is probable that these were destroyed by processes responsible for the alteration of the larger spicules to crystalline silica. The assemblage of forms obtained from the two localities is also interesting because of the abundant presence of hexactinellid remains. In modern seas these forms are confined almost exclusively to the deeper waters. The nature of the deposits in which the fossil spicules occur and the associated fauna, however, indicate clearly that representatives of this order formerly inhabited very shallow seas.

Phylum PORIFERA

Class SILICISPONGIA

Order MONACTINELLIDA

Genus RENIERA Schmidt

Certain fossil sponge spicules of distinctive form which are not uncommon in Carboniferous deposits in several parts of the world are

referred to the genus *Reniera* on account of their close resemblance to the spicules of this modern sponge.

RENIERA ARCA J. M. WELLER, N. SP.

Plate 15, figures 1-5.

This species is known only from smooth, cylindrical, curved spicules of somewhat variable size and form. Large examples measure about 1.8 mm. in length and vary from 0.13 to 0.22 mm. in thickness. The spicules may be of nearly uniform thickness throughout with blunt rounded ends or they may taper gradually toward the extremities which in a few specimens are fairly acute. The curvature is not uniform but takes place principally at two loci thus giving the spicule a rather angular form.

This species most closely resembles in size and shape *R. carteri* Hinde from the Lower Carboniferous limestone of Scotland. The larger spicules of the Scotch form, however, are less curved and not as sharply angular as the Indiana species.

Lower Pennsylvanian, Warren County, Indiana.

RENIERA SILIQUA J. M. WELLER, N. SP.

Plate 15, figures 6-16.

The detached spicules of this species are cylindrical, smooth and curved. The specimens observed average about 2 mm. in length and are all rather uniformly about 0.2 mm. in thickness. The spicules commonly taper slightly toward both extremities and may terminate in round blunt ends or project more acutely. The curvature is gentle and more or less uniform. The more curved forms present a slight suggestion of angularity. In the least curved specimens the inside edge of the spicule

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EXPLANATION OF PLATE 15

All figures enlarged 15 times

FIGS. 1-5.—*Reniera arca* J. M. Weller, n. sp. Cotypes, Warren County, Indiana.

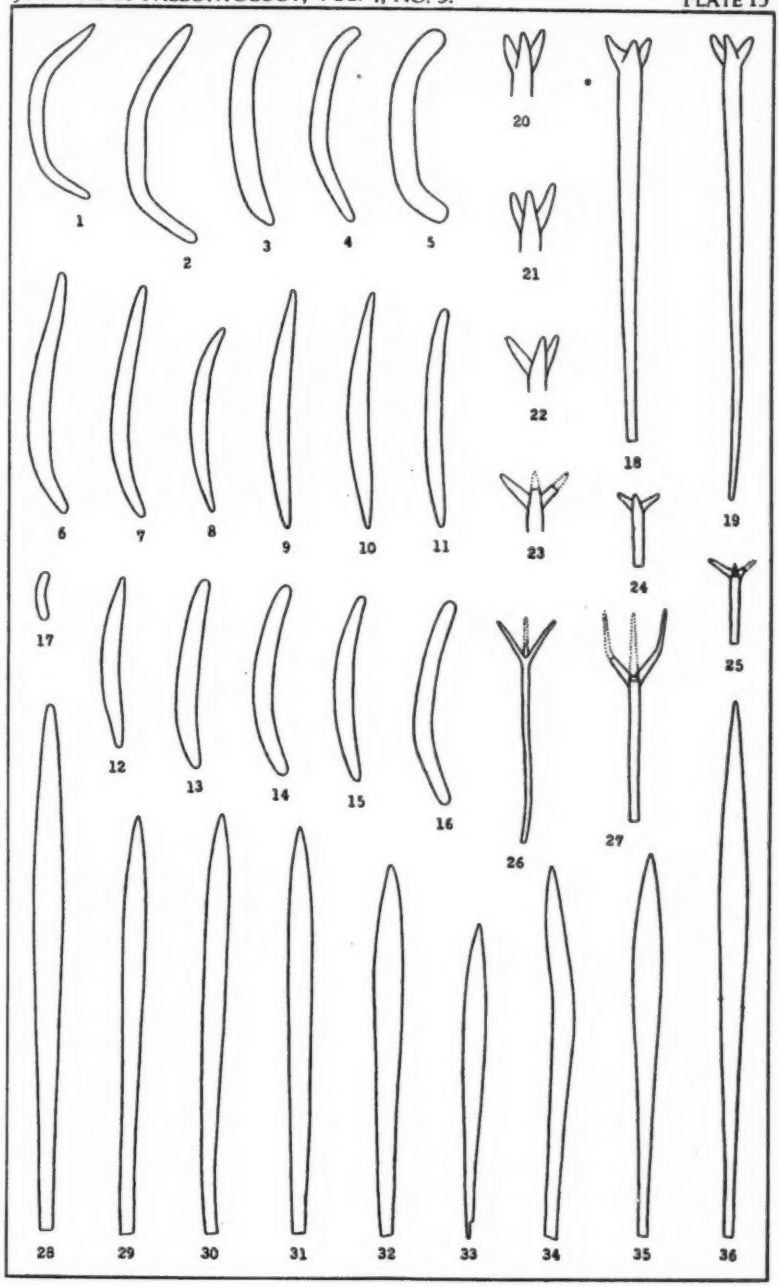
6-16.—*Reniera siliqua* J. M. Weller, n, sp. Rock Island County, Illinois, 12-16 are the cotypes.

17.—*Reniera phaseola* J. M. Weller, n. sp. Rock Island County, Illinois. See also Pl. 20, figure 3.

18-23, 28-32.—*Geodites pateus* J. M. Weller, n. sp. Warren County, Indiana. 18 and 19 are the cotypes. 28-32 monaxons referred to this species.

24-26, 33-36.—*Geodites carbonarius* (Ulrich), Rock Island County, Illinois. 33-36, monaxons referred to this species.

27.—*Geodites* sp. Rock Island County, Illinois.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is nearly straight and the curve of the outer edge is determined by the tapering of the spicule toward the ends.

The spicules of this species resembles *R. arca* Weller in size but are much less curved. They are somewhat less angular and not uncommonly are more acutely terminated than *R. carteri* Hinde.

Lower Pennsylvanian, Rock Island County, Illinois.

RENIERA PHASEOLA J. M. WELLER, N. SP.
Plate 15, figure 17; Plate 20, figure 3.

This species is based upon a specimen which shows a large number of tiny, smooth, cylindrical, curved spicules lying in an irregular mass. The spicules are quite uniform in size, being about 0.45 mm. in length and 0.08 mm. in thickness. The ends do not taper but are rounded and blunt and in some cases even slightly swollen. They are also quite uniform in shape. The curvature is slight and mostly restricted to the mid-length but the spicules are not angular in appearance.

These spicules are much smaller than those designated as *R. arca* or *R. siliqua*. They closely resemble the British species *R. clavata* Hinde but are not so generally possessed of tumid extremities.

Lower Pennsylvanian, Rock Island County, Illinois.

ORDER TETRACTINELLIDA

GENUS GEODITES CARTER

The genus *Geodites* was proposed for the reception of a group of fossil sponges, first appearing in the Carboniferous period, which possess spicules composed of a long shaft with three small summit-rays. Such spicules closely resemble certain skeletal elements of a group of modern sponges of which *Geodia* is a representative. The modern genera are distinguished by features that can not be recognized in the detached fossil spicules.

GEODITES PATEUS J. M. WELLER, N. SP.
Plate 15, figures 18-23, 28-32.

The spicules are composed of a long stout shaft-ray and three short blunt head-rays. The largest specimen observed measures 4.3 mm. in length. The shaft-ray is nearly straight, cylindrical and smooth, and tapers uniformly from the junctions of the head-rays at which position large specimens attain a thickness of 0.16 to 0.22 mm. At the other end the shaft-ray probably terminated acutely but in all observed specimens the tip has been broken off.

The head-rays vary in length from 0.3 to 0.4 mm. They are stout near their junction with the shaft, taper to rounded extremities and in some cases are slightly curved inward. They commonly diverge from the shaft to form angles of 90 degrees or less with each other.

Associated with these pronged spicules are numerous nearly straight smooth cylindrical cigar-shaped monaxons which are believed to have come from the same sponges. These spicules attain a maximum length of nearly 5 mm. They are asymmetrical longitudinally and the greatest thickness, which may reach nearly 0.3 mm., is attained nearer one end of the spicule than the other. From their thickest portions these spicules taper gradually and nearly uniformly in each direction. The termination of the shorter end of the spicule is rather acutely rounded while the other end is abruptly truncated.

These spicules are comparable in size to those of the British Carboniferous species *G. antiquus* Hinde but differ from them in the more tapering nature of the shaft-ray and the commonly less oblique disposition of the summit-rays.

Lower Pennsylvanian, Warren County, Indiana.

GEODITES CARBONARIUS (ULRICH)

Plate 15, figures 24-26, 33-36.

Hystriospongia carbonaria ULRICH, 1890, *Illinois Geol. Survey*, Vol. 8, p. 245, Pl. 6, fig. 3, text-fig. 1, p. 246. Near the base of the Coal Measures at Seville, Illinois.

No unbroken specimens of this species have been observed. The shaft-ray is cylindrical, smooth, nearly straight and tapers only slightly or not at all for a distance of 1.7 mm. below the head-rays, this being the length of the shaft of the largest specimen in the collection. Thickness of the shafts is rather uniform, about 0.08 mm. The head-rays form an angle between themselves of 90 degrees or more. They may attain a length of 0.44 mm. and are slender and rather acutely terminated.

Associated with these tetraxons are monaxons similar in size and form to those which accompany *G. pateus*.

These spicules are referred to Ulrich's species described from the same horizon cropping out at a locality in Fulton County, 70 miles distant. They differ from the previously described *G. pateus* in the much more slender forms of the tetract spicules.

Ulrich's type specimen, which cannot now be located, is described as being a collapsed mass of spicules seeming to represent the entire sponge. In this mass of spicules, which consisted largely of biacerate forms about 1 mm. in length, a few four-rayed spicules occurred such as

those described above. The new genus which Ulrich proposed for the reception of this specimen was said to be characterized by the association of many monaxons with very few tetraxons. I feel that such a definition is inadequate for fossils such as these which are very fragmentary and usually subject to dispersal, and prefer to refer these spicules to the more generalized, doubtless unnatural group included in *Geodites*.

Lower Pennsylvanian, Rock Island County, Illinois.

GEODITES? DEFLECTERUS J. M. WELLER, N. SP.
Plate 16, figures 32 and 33.

These tetractinellid spicules consist of a long slender shaft-ray and three small recurved head-rays. No complete specimens have been obtained. The most perfect is 1.9 mm. in length. Its incomplete shaft is cylindrical and smooth, 0.08 mm. in thickness, and does not taper noticeably. The head-rays of these spicules are joined to the shaft at nearly right angles and are uniformly and gently recurved. They vary from 0.16 to 0.24 mm. in length and taper gradually to acutely rounded ends.

These spicules differ from the common types referred to *Geodites* in the recurvature of the summit-rays.

Lower Pennsylvanian, Warren County, Indiana.

GEODITES? BIFURCATUS J. M. WELLER, N. SP.
Plate 16, figures 30 and 31.

This species is based upon isolated tetractinellid spicules that consist of a stout shaft-ray and three smaller summit-rays each of which bifurcate. No perfect specimen has been collected. The shaft is cylindrical, smooth and straight and tapers gradually from the summit.

EXPLANATION OF PLATE 16

All figures enlarged 15 times

FIGS. 1-18.—*Hyalostellia diabola* J. M. Weller, n. sp. Cotypes, Rock Island County, Illinois.

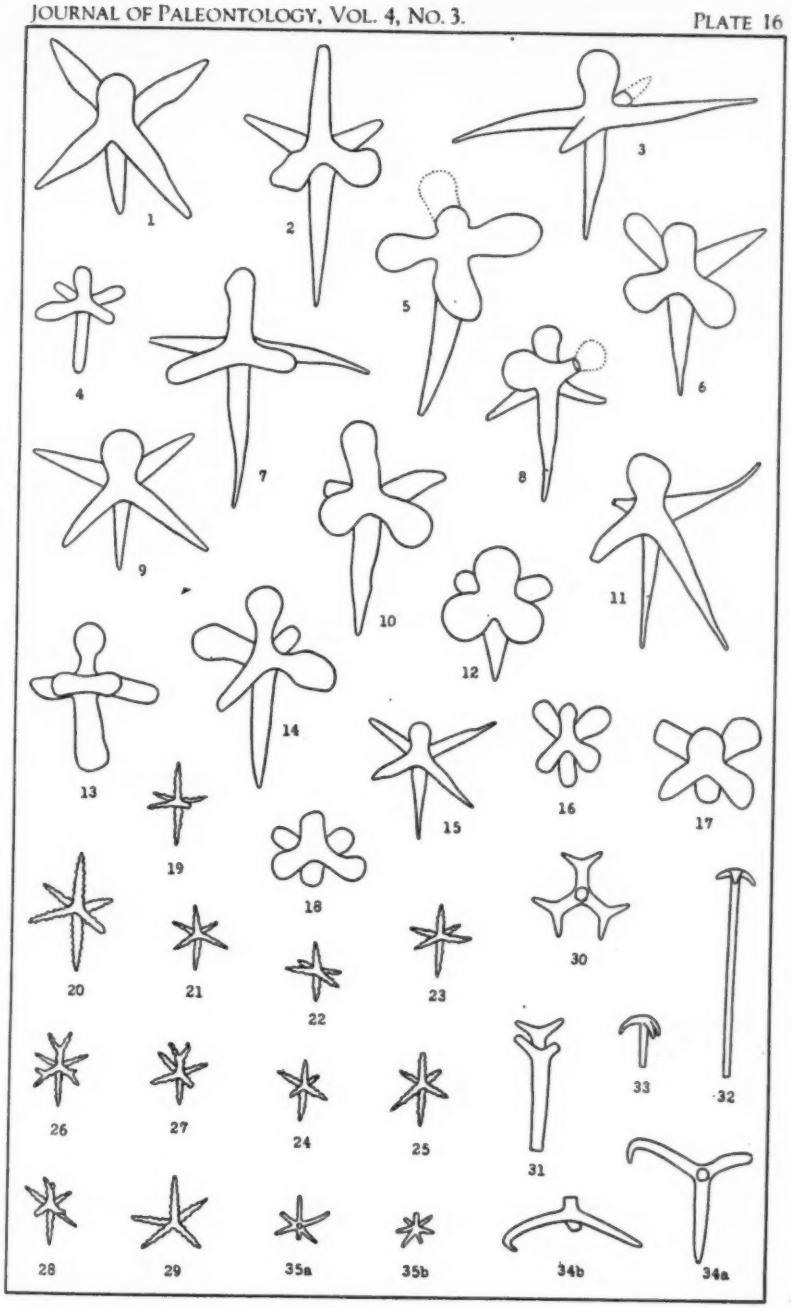
19-29.—*Rhakistella alba* J. M. Weller, n. sp. 19-24, cotypes, Warren County, Indiana. 25, Rock Island County, Illinois. 26-27, spicules with bifurcated rays, Rock Island County, Illinois. 28, the same, Warren County, Indiana. 29, irregular five-rayed spicule, Warren County, Indiana.

30-31.—*Geodites? bifurcatus* J. M. Weller, n. sp. Cotypes, Warren County, Indiana.

32-33.—*Geodites? deflecterus* J. M. Weller, n. sp. Cotypes, Warren County, Indiana.

34 a-b.—*Peronella? dubia* J. M. Weller, n. sp. Holotype, Warren County, Indiana.

35 a-b.—*Tholiasterella? trunca* J. M. Weller, n. sp. Holotype, Warren County, Indiana. 35b, oblique view.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The most complete, which is, however, broken, measures 0.84 mm. in length and is 0.16 mm. thick at the junction of the head-rays. The head-rays are straight and stout and make with each other angles somewhat greater than 90 degrees. Each of these rays divides into two parts at a position about 0.3 mm. from the central axis. The furcations are symmetrically disposed nearly in a plane normal to the main axis. Each is about 0.22 mm. in length and tapers evenly to an acutely rounded end.

The bifurcation of the head-rays distinguishes this species from the common type of *Geodites* spicule.

Lower Pennsylvanian, Warren County, Indiana.

GEODITES SP.
Plate 15, figure 27.

Associated with the specimens referred to *G. carbonarius* is a single tetractinellid spicule with broken shaft and two broken head-rays. The remaining head-ray is angularly deflected at about mid-length to a direction nearly parallel to the shaft. Aside from the nature of the head-ray this spicule closely resembles a large skeletal element of *G. carbonarius* It is not known whether this peculiarity is an original, normal character of the spicule or whether it is an aberrant form or one resulting from deformation during fossilization.

Lower Pennsylvanian, Rock Island County, Illinois.

ORDER HEXACTINELLIDA

GROUP LYSSAKINA

GENUS HYALOSTELLIA ZITTEL

These fossil sponges are known principally from detached spicules, and are composed partly of simple hexactinellid spicules, one axis of which is commonly much elongated, and partly of spicules one or more rays of which are inflated, spined, reduced to rounded knobs or even absent. The sponges were anchored to the bottom by a root-tuft composed of elongated spicules which are not uncommonly observed to terminate in four recurved rays.

HYALOSTELLIA DIABOLA J. M. WELLER, N. SP.
Plate 16, figures 1 to 18.

The spicules are hexactinellids of highly varied form possessing one or more rays ending in blunt, rounded terminations which are commonly

more or less swollen. The remaining rays are nearly straight and taper toward acute extremities. The several axes of these spicules are of rather uniform length in individual specimens except for shortening which may occur in one or more of the tumid rays. The greatest dimension of the spicules is observed to vary between 0.7 and 2.8 mm. Thickness of the rays shows little relation to their length.

It is possible that these spicules and those referred to *Hexactinellida delicatula* (Ulrich) were derived from the same sponges. No intermediate or connecting forms have been observed, however, and I have therefore decided to give these peculiar spicules a distinctive name.

Lower Pennsylvanian, Rock Island County, Illinois.

Genus RHAKISTELLA J. M. Weller, n. gen.

This genus is proposed for the reception of isolated hexactinellid spicules of symmetrical form which are characterized by the presence of small, equally sized and spaced spines. One or more of the six primary rays may bifurcate sharply.

RHAKISTELLA ALBA J. M. Weller, n. sp.

Plate 16, figures 19-29.

The spicules referred to this species are fairly regular hexactinellids whose axes vary in length from 0.55 to 1.10 mm. with thicknesses of 0.06 to 0.09 mm. The rays taper gradually and rather uniformly from the center of the spicule to acute terminations. Specimens have been observed in which one to three of the rays bifurcate at about mid-length into two prongs which diverge at an angle somewhat less than 90 degrees. The surface of all the rays are thickly set with minute, equally sized and spaced spines which are directed at right angles to the rays.

The symmetrical form and spinose nature of these spicules is distinctive.

Lower Pennsylvanian, Rock Island County, Illinois.

HEXACTINELLIDA DELICATULA (Ulrich)

Plate 17, figures 1-27; Plate 20, figure 5.

Hyalostellia delicatula Ulrich, 1890, *Illinois Geol. Survey*, Vol. 8, p. 246, text-figs. 2, 3. Near the base of the Coal Measures at Seville, Illinois.

A considerable variety of spicules is referred to this species which has never been described. These include fragmentary hexactinellid

spicules composed of long, comparatively slender and very gently tapering rays which are commonly more or less curved (Pl. 17, figs. 1-7). These appear to be connected by intermediate forms (Pl. 17, figs. 8-15) with smaller and more regular but not uncommonly somewhat distorted spicules with rays tapering to more or less acute ends (Pl. 17, figs. 16-27). The largest spicule, which is however incomplete, measures nearly 5 mm. in length. The rays of this specimen attain a maximum thickness of about 0.11 mm. Spicules of intermediate type possess some rays that are long, slender, curved, and gradually tapering, and others that are short and acute. The smaller, more regular spicules are commonly much more stout.

Associated with hexactinellid spicules of these types are fragments of coarse linear spicules which appear to have been derived from the root-tufts of this species. A bundle of such spicules has been found to which a number of the hexactinellid forms are irregularly attached. This bundle is a little more than 1 cm. in length and is composed of about 20 of the coarse linear spicules. The separated fragments of these spicules that have been examined attain a maximum length of 7.5 mm. and a maximum thickness of 0.36 mm. The specimens are all broken at both ends and none have been found that possess the four short recurved anchoring rays that commonly terminate them below. They are all more or less irregularly curved. Linear fragments of finer spicules occur with the coarser ones, which are tentatively also referred to the root-tuft of this species.

Ulrich gave no description of this species and his type material, which consisted of a few separate hexactinellids and fragments of the root-tuft spicules, cannot now be located. His specimens were obtained from the same horizon as the Rock Island County spicules and the two that are illustrated in his wood-cut so closely resemble some of those recently obtained from the other locality that there can be little doubt as to their identity.

It has been customary for paleontologists to refer Paleozoic hexactinellid spicules which are accompanied by fragmentary root tufts to the genus *Hyalostellia*. It appears to me that the possession of a root-tuft is not a generic character, since many varieties of modern forms are anchored by such a structure, and I prefer to restrict *Hyalostellia* to

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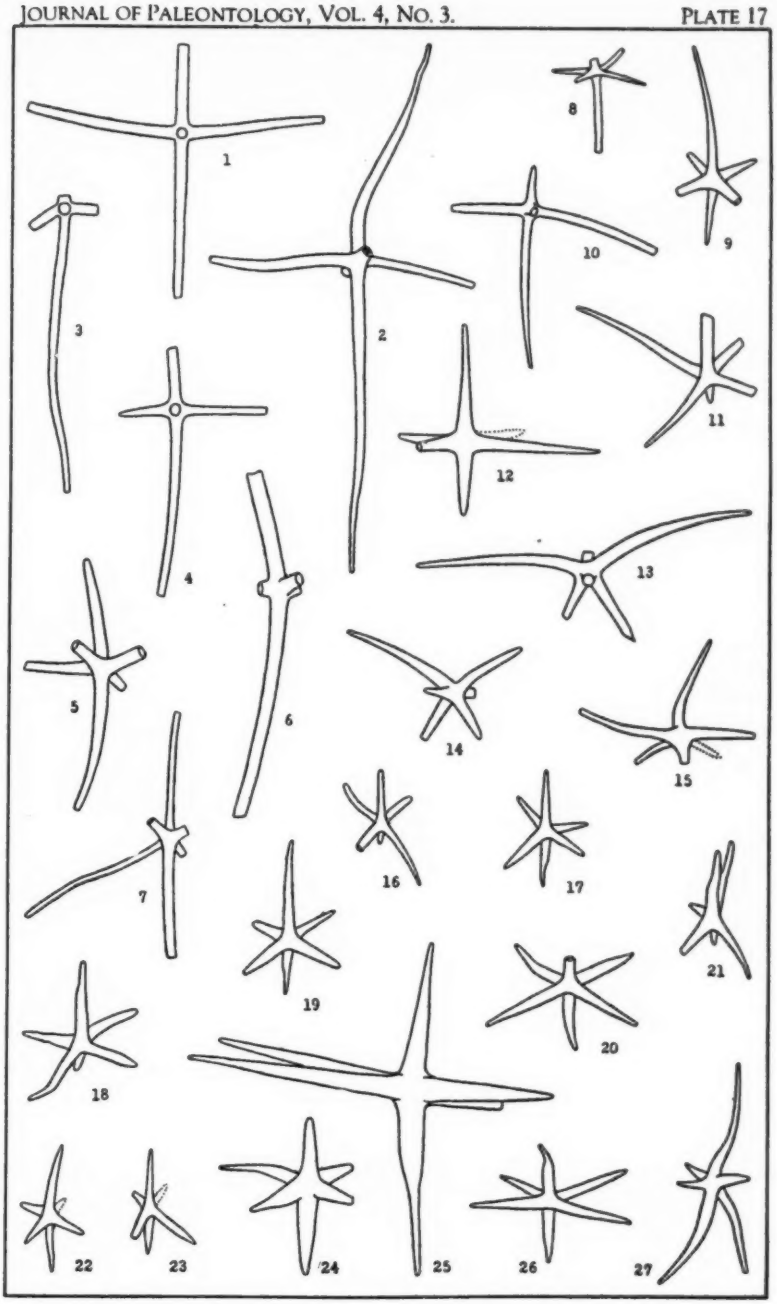
EXPLANATION OF PLATE 17

All figures enlarged 15 times

FIGS. 1-27.—*Hexactinellida delicatula* (Ulrich), Rock Island County, Illinois.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include only those forms which are at least partly composed of hexactinellids with one or more inflated rays.

It is possible that the spicules described as *Hyalostellia diabola* may have been derived from the same sponges as those which yielded the spicules that are here identified as *Hexactinellida delicatula*. If this can be established the latter forms must again be referred to *Hyalostellia* and *H. diabola* will become a synonym.

Lower Pennsylvanian, Rock Island County, Illinois.

Order HETERACTINELLIDA

Genus ASTERACTINELLA Hinde

The form of the entire sponge is unknown. The skeleton consists of relatively large spicules which are composed of a variable number of unequal rays radiating in different directions from a common center.

ASTERACTINELLA AUDAX J. M. Weller, n. sp.
Plate 18, figures 1-14; Plate 20, figure 4

Associated with the other sponge spicules obtained in Warren County, Indiana, are a large number of forms which are conspicuous because of their comparatively large size, great variability, and brownish color, which contrasts strongly with the whiteness of the other spicules. They are composed of a variable number of unequal rays arranged in an irregular manner. Many individuals are composed of several rays, notably five or six, radiating from a common center nearly in a plane, at right angles to which other rays extend upon each side. In place of a single ray in the latter position there may be two stout diverging rays or a group of more slender rays variously directed. The larger spicules attain a size of over 4 mm. in greatest dimension and the principal rays, which commonly taper irregularly to rounded ends, are 0.5 mm. thick although some specimens are much more swollen.

Numerous spicules have been obtained which appear to be irregularly intergrown. This is probably the original condition of the spicules and not a result of fossilization as Hinde has suggested in connection with the description of somewhat similar British specimens. One mass of intergrown spicules (Pl. 20, fig. 4) is believed to show the arrangement of the spicules at the surface of the sponge. This mass possesses a nearly

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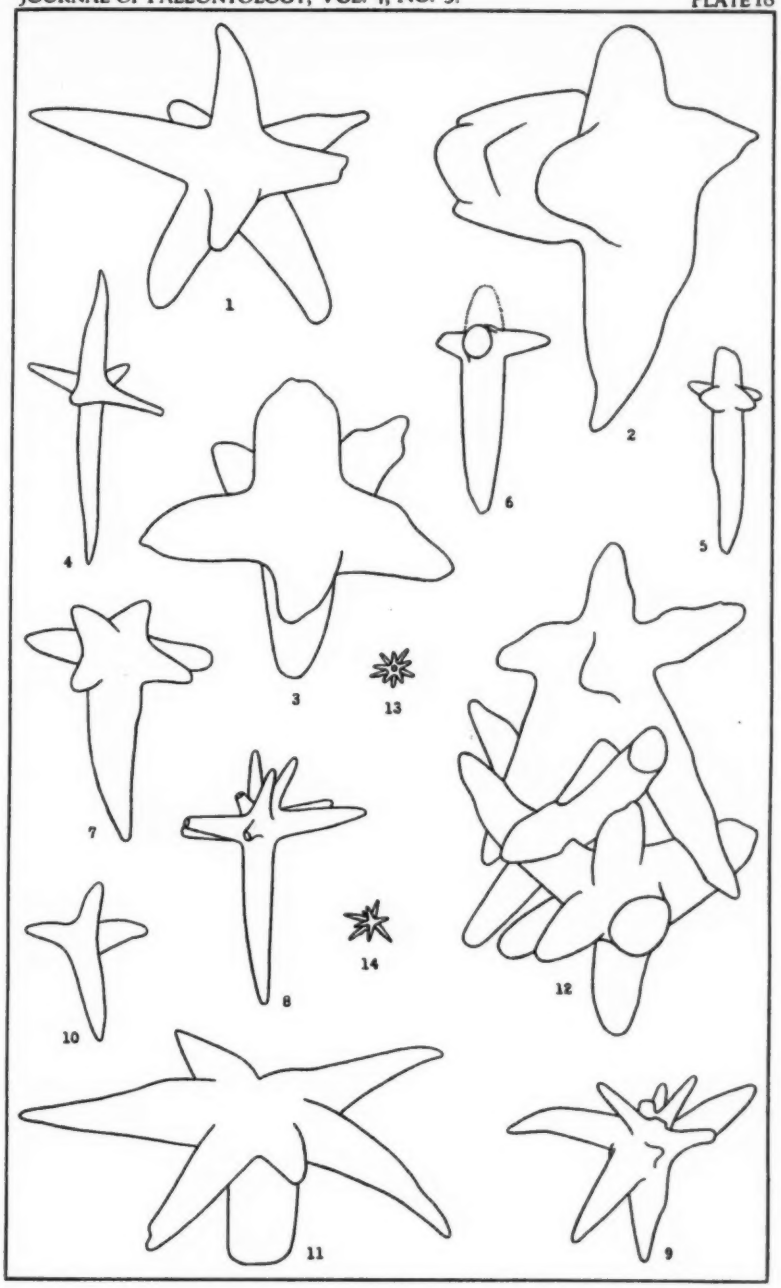
Explanation of Plate 18

All figures enlarged 15 times

Figs. 1-14.—*Asteractinella audax* J. M. Weller, n. sp. Warren County, Indiana. 1-11, cotypes. 12, group of intergrown spicules. 13-14, flesh spicules.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9

even surface formed by closely set, flat-topped spicules similar to that shown in Plate 18, figure 11.

Associated with these large spicules are several tiny ones composed of a large number of slender rays of nearly equal length which radiate in all directions from a common center. They are referred to the same species as the larger forms on account of their similar brownish tint. It is not unlikely that they are of the nature of flesh spicules from the interior of the sponge body.

Hinde[3] has stated that he was able to recognize no semblance of hexactinellid structure in spicules of a somewhat similar nature collected in Scotland. Certain spicules of the Indiana species (Pl. 18, figs. 4-5) however are distinctly hexactinellid and it does not seem impossible that the irregular form of the majority is due to furcation of six primary rays at points close to their centers of origin. A few examples such as that represented by Plate 18, figure 2 shows incipient furcation at various positions along one or more rays and indicates that a somewhat similar development may have occurred more completely at an earlier stage. If the irregular form of the spicules has resulted from such furcations this form should be removed from the Heteractinellida, which appears to be an artificial group, and placed with the Hexactinellida.

These Pennsylvanian spicules are somewhat similar to forms obtained from the Salem limestone of Indiana which have been interpreted as holothurian spicules.[4] The Salem specimens are comparable in size and of somewhat the same form but are composed of calcite.

Lower Pennsylvanian, Warren County, Indiana.

Genus THOLIASTERELLA Hinde

The form of the sponge is unknown. The spicules consist of a shaft which supports at its summit a variable number of rays radiating in more or less the same plane.

[3]G. J. Hinde, "A Monograph of the British Fossil Sponges, *Paleontolographical Soc.*, 1887, pp. 172-173 (1888).

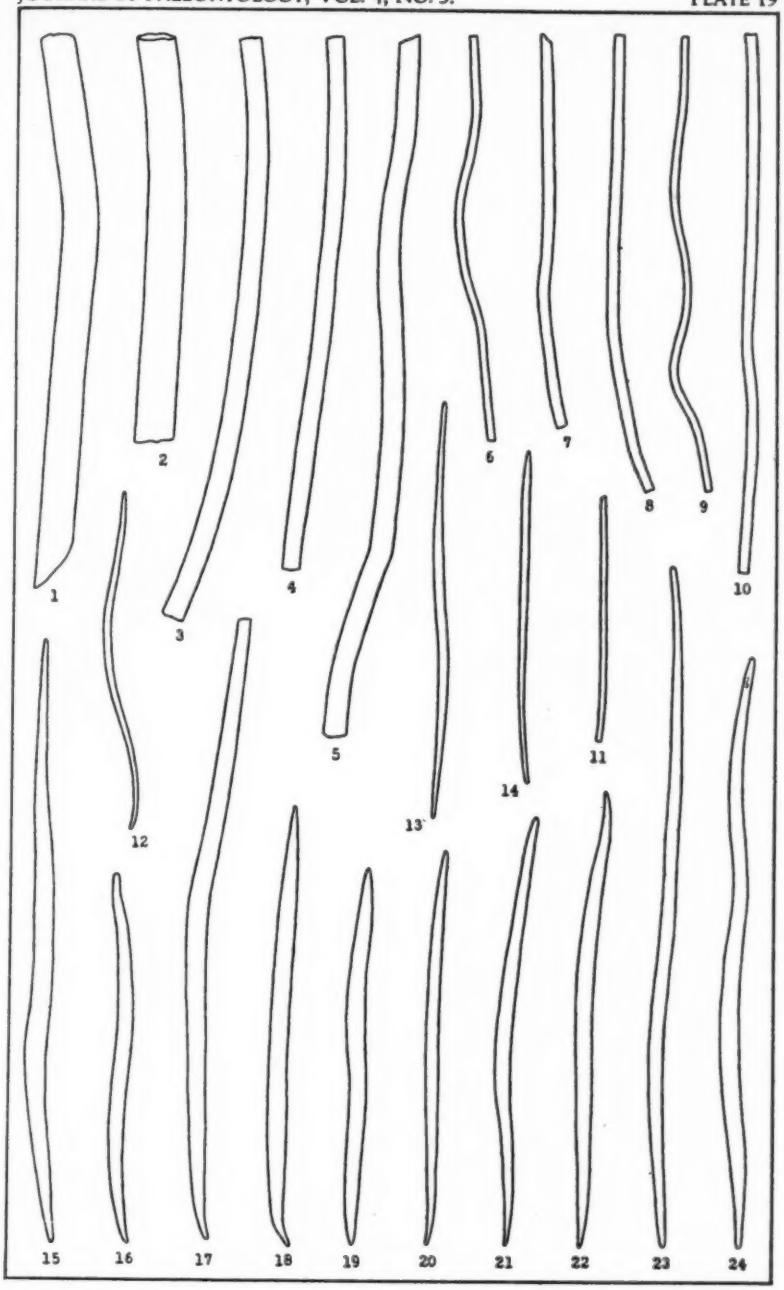
[4]J. W. Beede, "The Fauna of the Salem Limestone of Indiana," *Ind. Dept. Geol. and Nat. Resources*, 30th Ann. Rept. (1906), p. 1242, Pl. 19, figs. 9-17.

Explanation of Plate 19

All figures enlarged 15 times

Figs. 1-11.—*Hexactinellida delicatula* (Ulrich), Rock Island County, Illinois. 1-5, stout monaxial fragments believed to have come from root-tuft of this species. 6-11, slender fragments possibly of similar origin.

12-24.—Monaxons of unknown affinities. 1-19, Rock Island County, Illinois. 20-24, Warren County, Indiana.



UNIV. OF MICH.

THOLIASTERELLA? TRUNCA J. M. WELLER, N. SP.
Plate 16, figures 35 a-b.

A single incomplete spicule has been found consisting of a shaft-ray and six head-rays extending nearly in a plane. The shaft is cylindrical, smooth, about 0.03 mm. in thickness and is broken off short. The head-rays are slender, nearly symmetrically arranged and were probably originally almost uniformly about 0.3 mm. in length. They are nearly straight and taper very gently.

Lower Pennsylvanian, Warren County, Indiana.

CLASS CALCISPONGIA

FAMILY PHARETRONES

GENUS PERONELLA ZITTEL

The skeleton of this type of sponge consists of an irregular meshwork of anastomosing fibers composed of three- and four-rayed spicules of large or moderate size surrounded by similar but smaller spicules.

PERONELLA? DUBIA J. M. WELLER, N. SP.
Plate 16, figures 34 a-b.

A single spicule has been found which consists of three smooth cylindrical rays about 0.75 mm. in length, arranged nearly in a plane, and a fourth broken ray directed at right angles to these, all attaining a thickness of about 0.12 mm. The three rays first mentioned taper gradually and two end in acurely rounded terminations. One of these rays is straight, another gently curved and probably broken at the end, and the last is sharply recurved and hooked.

This spicule is preserved in finely crystalline silica essentially similar to all the others obtained from this locality. It is referred to the Calcispongia with considerable doubt (although calcareous spicules are

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EXPLANATION OF PLATE 20

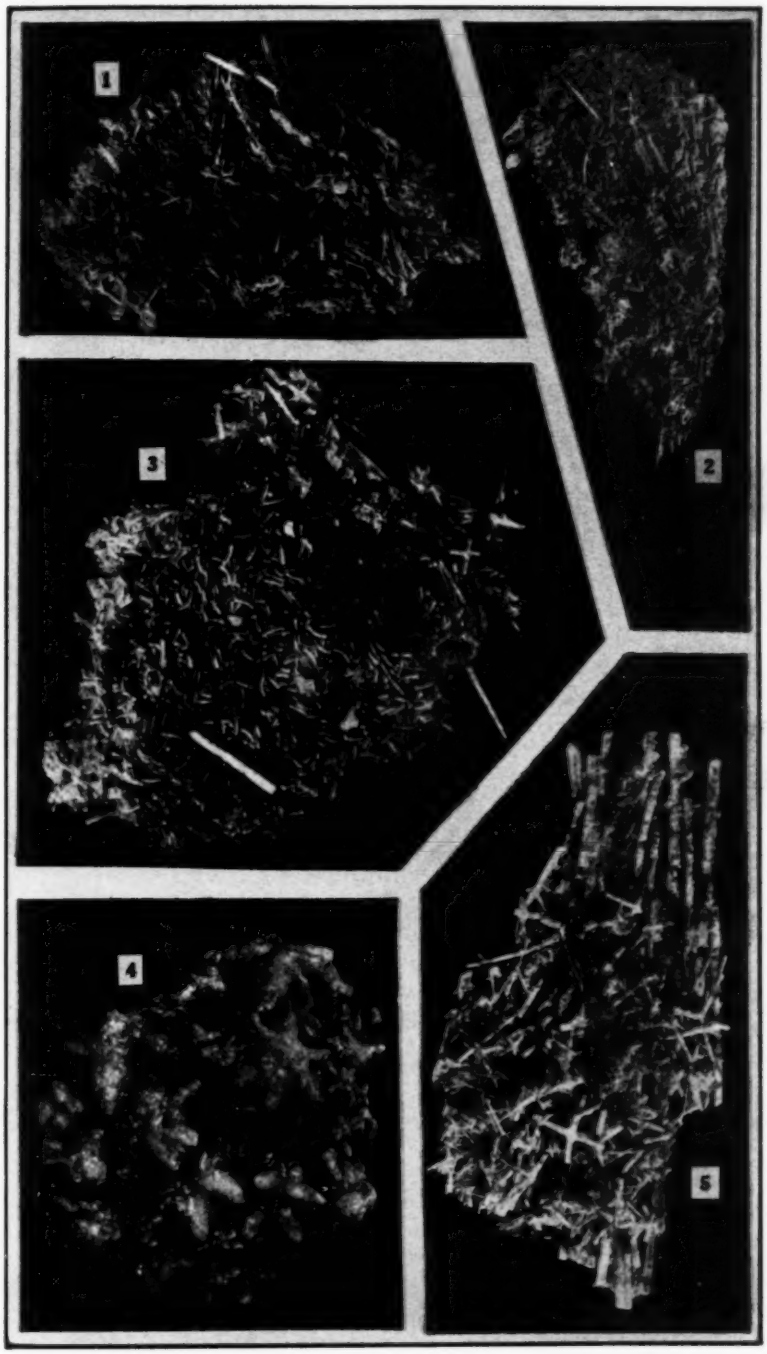
All figures enlarged 7½ times

FIGS. 1-2.—Felted masses of sponge spicules obtained by treating limestone with acid. 1, Rock Island County, Illinois. 2, Warren County, Indiana.

3.—*Reniera phaseola* J. M. Weller, n. sp. Holotype, a mass of scattered spicules, Rock Island County, Illinois.

4.—*Asterospongia audax* J. M. Weller, n. sp. Mass of intergrown spicules, Warren County, Indiana.

5.—*Hexactinellida delicatula* (Ulrich). Portion of root-tuft and associated six-rayed spicules, Rock Island County, Illinois.


1
2
3
4
5

not uncommonly replaced by silica) because of its close resemblance to the type of spicule that is considered characteristic of the genus *Peronella*.

Lower Pennsylvanian, Warren County, Indiana.

INCERTAE SEDIS

Monaxial Sponge Spicules

Plate 19, figures 12-24.

Biacerate, monaxial spicules varying in length up to 6.5 mm. and in thickness to 0.2 mm. have been obtained in considerable numbers. These spicules are commonly slightly sinuous and taper gradually toward both ends which in most cases are rather acute.

While some of these spicules may have been derived from sponges that did not possess skeletal elements of other types, they present no characters to distinguish them from similar spicules which are known to be present in many different kinds of sponges.

Lower Pennsylvanian, Rock Island County, Illinois, and Warren County, Indiana.

CRETACEOUS SECTION OF MAVERICK COUNTY, TEXAS[1]

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ABSTRACT

The general lithologic and micropaleontologic character of the subdivisions of the Cretaceous are briefly described from well sample determinations. The stratigraphic column in Maverick County is compared with the Uvalde and Bexar County sections.

INTRODUCTION

In the past few years a number of deep wells have been drilled in central Maverick County, Texas, revealing an unusually thick section of nearly conformable Cretaceous deposits. This particular area is regarded as a part of the northern margin of the so-called Rio Grande Embayment or geosyncline.

The location of the deep tests mentioned is about twenty miles north and northeast of the town of Eagle Pass, Texas, on the Mexican border. This drilling was a part of a rather extensive exploration program on a long, broad up-fold, that extends northwest-southeast through Maverick County, and is called locally the Chittim anticline. The writer has also had access to well data from other parts of Maverick and adjacent counties and from the state of Coahuila, Mexico, southwest of Eagle Pass.

The purpose of this paper is to note the more important lithologic features and to list the micro-fossils found in the samples of cable-tool cuttings that have been studied. The micropaleontological work on the Maverick County subsurface section has not been completed. Only a few forms have been specifically identified. Many new species and varieties of Foraminifera and Ostracoda which exist in this newly studied region are mentioned, if at all, only by genera.

STRATIGRAPHY

The following table gives the Cretaceous formations that are exposed on and adjacent to the Chittim uplift, and the approximate thickness of the corresponding sections to the north and east.

The wells drilled on the crest of the Chittim uplift begin in lower San Miguel (Navarro) or upper Upson (Taylor). The following general

[1]Published by permission of the Rycade Oil Corporation, Houston, Texas.

TABLE I

CRETACEOUS FORMATIONS OF SOUTHWEST TEXAS

	Texas		*Bexar County* [a] Approximate thickness in feet	*Uvalde County* [b] Approximate thickness in feet	*Maverick County* [c] Maximum thickness in feet	*Mexico*	*Colorado*
Upper Cretaceous	Navarro		450+	Escondido 550	Escondido 1,675 Olmos 434 San Miguel 581	Velasco	Fox Hills Pierre
	Taylor		550	Anacacho 750	Upson 585	Mendez	
	Austin		443	406	745	Papagallos	Niobrara
	Eagle Ford		43	465	939	San Felipe	Benton
Lower Cretaceous	Washita	Buda	100	100	160	Tamaulipas or Tamasopa	Dakota sandstone
		Del Rio	78	137	279		
		Georgetown	46	73	175		
	Fredericksburg	Edwards	724	586	905		
		Comanche Peak	75	0(?)	0(?)		
		Walnut	20	0(?)	0(?)		
	Trinity	Glen Rose	1,785	2,250+	3,600+		
Total thickness			4,314	5,317	10,078		

a Upper Cretaceous near San Antonio; Lower Cretaceous in southwest Bexar County from R. A. Jones, Bull. Amer. Assoc. Petroleum Geol., vol. 10, pp. 768-74, 1926.
b Near Uvalde and in southwest part of county.
c Upper Cretaceous near Eagle Pass; Lower Cretaceous in central Maverick County.

descriptions of the subsurface section begins with the lower 200 feet of the San Miguel formation.

San Miguel sand. Gray and yellow, calcareous sandstones and sandy clays, with glauconite, selenite, pyrite and mica. The sand consists for the most part of small, sub-rounded, clear and smoky quartz grains,

with dark-colored chert and magnetite. The beds of this formation are quite fossiliferous and include numerous megascopic shells and casts. The clays of the San Miguel contain an abundance of micro-organic remains and amply fulfill the requisites of a source rock. The sandstone members are ideal reservoirs for oil and gas.

Foraminifera
- *Anomalina* sp.
- *Cibicides* sp.
- *Lenticulina velascoensis* White, n. var.
- *Lenticulina* cf. *reniformis* (d'Orbigny)
- *Lentinulina* sp.
- *Nodosaria* sp.
- *Textularia* sp. (?)
- *Vaginulina* cf. *lineara* (Carsey), n. var.

Ostracods
- *Bairdia* sp.
- *Bythocypris* sp.
- *Cythereis* sp.

Upson clay. Yellowish-gray to dark bluish-gray, calcareous clay beds, in part shaly. They contain aragonite, selenite, pyrite, mica and occasionally glauconite and magnetite. Numerous shell fragments and echinoid spines are noted in the washed samples. The clays where exposed at the surface contain many megascopic shells and casts.

Foraminifera
- *Anomalina* cf. *taylorensis* Carsey
- *Anomalina* sp.
- *Bolivina latticea* Carsey
- *Bolivina* cf. *plaita* Carsey
- *Clavulina trilatera* Cushman, n. var.
- *Discorbis* cf. *correcta* Carsey
- *Frondicularia projecta* Carsey
- *Guadryina* cf. *bulletta* Carsey
- *Globigerina cretacea* d'Orbigny
- *Globigerina* cf. *quadrata* White
- *Globorotalia* sp. (?)
- *Globotruncana conica* White, n. var.
- *Globotruncana rosetta* (Carsey)
- *Globotruncana* sp.
- *Gümbelina* cf. *elegans* (Rzehak)
- *Gümbelina globifera* (Reuss)
- *Gümbelina globulosa* (Ehrenberg)
- *Gümbelina* cf. *ultimatumida* White
- *Haplophragmoides* cf. *diagonsis* Carsey
- *Kyphopyxa christneri* (Carsey)
- *Lagena* cf. *hispida* Reuss
- *Lagena* cf. *incidenta* Carsey
- *Lenticulina gibba* (d'Orbigny)
- *Lenticulina* cf. *grata* (Reuss)
- *Lenticulina* cf. *macrodisca* (Reuss)
- *Lenticulina reniformis* (d'Orbigny)
- *Lenticulina* cf. *rotulata* (Lamarck)
- *Lenticulina* sp.
- *Nodosaria alternata* Carsey
- *Nodesaria* cf. *ambigua* Neugeboron
- *Nodosaria communis* d'Orbigny
- *Nodosaria fragilis* Carsey
- *Nodosaria* cf. *intrasegma* Carsey
- *Nodosaria* cf. *laevigata* Nilsson
- *Nodosaria obliqua* (Linnaeus)
- *Nodosaria* cf. *sceptiformis* Gümbel
- *Nodosaria* cf. *vertebralis* Batsch
- *Nodosaria* sp.
- *Planulina* cf. *dayi* White
- *Psammosphaera laevigata* White
- *Pseudotextularia varians* Rzehak, n. var.
- *Pseudotextularia* sp.
- *Quinqueloculina* sp.
- *Robulus* cf. *crepidula* (Fichtel and Moll)
- *Robulus cultratus* Montfort
- *Rotalia* cf. *cretacea* Carsey
- *Spiroloculina* sp.
- *Textularia* cf. *nacataensis* White
- *Textularia* cf. *semicomplanata* Carsey
- *Textularia* sp.
- *Tritaxia* cf. *tricarinata* Reuss
- *Tritaxia* sp.
- *Vitriwebbina* sp. (?)

Ostracods
- *Bairdia obliqua* Alexander
- *Bairdia subdeltoidea rotunda* Alexander
- *Bairdia* sp.
- *Bythocypris* sp.
- *Cytheridea* sp.
- *Cythereis* sp.
- *Cytherella* sp.
- *Cytheropteron* sp.

Austin chalk. White chalk and chalky limestone, gray and brownish gray marl, and bluish-gray, chalky shale. Pyrite, mica flakes, aragonite and occasionally glauconite grains are present in the samples.

Foraminifera
- *Anomalina* sp.
- *Bulimina* sp.
- *Clavulina trilatera* Cushman n. var.
- *Flabellina* sp. (?)
- *Frondicularia* sp.
- *Gaudryina* cf. *retusa* Cushman
- *Globigerina cretacea* d'Orbigny
- *Globotruncana canaliculata* (Reuss)
- *Globotruncana rosetta* (Carsey)
- *Globotruncana* sp.
- *Gümbelina globifera* (Reuss)
- *Gümbelina globulosa* (Ehrenberg)
- *Gümbelina* sp.
- *Gyroidina* sp.
- *Kyphopyxa* cf. *christneri* (Carsey)
- *Kyphopyxa* sp.
- *Lagena* sp.
- *Lenticulina gibba* (d'Orbigny)
- *Lenticulina macrodisca* (Reuss), n. var.
- *Lenticulina* cf. *rotulata* (Lamarck)
- *Nodosaria* sp.
- *Planulina* sp.
- *Planoglobulina* cf. *acervulinoides* (Egger)
- *Psammosphaera laevigata* White
- *Pseudotextularia* cf. *varians* (Rzehak)
- *Pseudotextularia* sp.
- *Rotalia beccariiformis* (White), n. var.
- *Rotalia* sp.

Ostracods
- *Bairdia* cf. *subdeltoidea* (Münster)
- *Bythocypris* sp.
- *Cytheridea* sp.
- *Cythereis* sp.
- *Cytherella* sp.

Eagle Ford shale. White, gray and brown, thin, chalky limestones, with bluish-gray, brown and black, calcareous shales. Most of the samples of this formation are pyritic, and also contain bentonite, biotite flakes, glauconite and rarely marcasite. The upper 500 feet or more consist of alternating limestone and shale streaks, the lower part being essentially dark-colored, slightly bituminous shale. The Eagle Ford is known to be petroliferous in many parts of Texas and northern Mexico. It is not only a good source rock for oil and gas but may under certain conditions serve as a reservoir.

Foraminifera
- *Anomalina* cf. *eaglefordensis* (Moreman)
- *Anomalina* sp.
- *Bulimina* sp.
- *Globigerina cretacea* (d'Orbigny)
- *Globotruncana arca* (Cushman)
- *Globotruncana* cf. *canaliculata* (Reuss)
- *Globotruncana* sp.
- *Gümbelina globulosa* (Ehrenberg)
- *Gümbelina* cf. *globifera* (Reuss)
- *Gümbelina* cf. *elegans* (Rzehak)
- *Kyphopyxa* sp.
- *Lenticulina* cf. *gibba* (d'Orbigny)
- *Planulina* sp.
- *Rotalia* sp.

Ostracods
- *Cythereis* sp.
- *Cytherella* sp.

Buda limestone. Medium hard, grayish-white, sub-crystalline limestones and buff-gray to brown, granular limestones with numerous minute spherules of lime. Many of the fragments of this limestone contain narrow, irregular calcite veinlets. Occasionally the granular limestone ledges in the Buda contain small amounts of oil and gas.

The Buda limestone is regarded as the upper member of the Washita group (Lower Cretaceous). Because of the sudden distinct change from black shale (Eagle Ford) to hard, white limestone (Buda), the top of this formation is the first reliable subsurface marker in this region. The thickness of the formation has been found to be rather uniform over extensive areas.

Foraminifera
- *Globigerina cretacea* (d'Orbigny)
- *Globotruncana* cf. *conica* (White)
- *Globotruncana rosetta* (Carsey)
- *Gümbelina* sp.
- *Lenticulina* cf. *washitensis* (Carsey)
- *Nodosaria* sp.
- *Rotalia cretacea* Carsey, n. var.

Ostracods
- *Cytherella* sp.

Del Rio clays. Blue, gray, brown and black, calcareous clays, with shaly streaks and thick, brown, shaly limestone partings. Most of the formation contains a considerable amount of finely disseminated pyrite. These clays are well known to all drilling operators in this part of southwest Texas as the Del Rio "cave." Casing must be carried along while drilling through this formation because of the inability of these clays to form a wall without caving. The Del Rio clays contain some organic material and may or may not be a source rock for petroleum.

Foraminifera
- *Anomalina* sp.
- *Gaudryina filiformis* Berthelin
- *Globigerina cretacea* d'Orbigny
- *Globigerina washitensis* Carsey
- *Globigerina* sp.
- *Globotruncana* cf. *conica* White
- *Globotruncana* sp.
- *Gümbelina* sp.(?)
- *Lenticulina* cf. *washitensis* (Carsey)
- *Lenticulina* sp.
- *Nodosaria communis* d'Orbigny
- *Quinqueloculina* sp. undet.
- *Robulus* sp. (?)
- *Rotalia* cf. *cretacea* Carsey
- *Rotalia* sp.
- *Textularia conica* d'Orbigny
- *Textularia rioensis* Carsey
- *Textularia washitensis* Carsey

Ostracods
- *Bairdia* sp.
- *Bythocypris* sp.
- *Cythereis* sp.
- *Cytherella* sp.
- *Paracypris* sp.

Georgetown limestone. Gray, and buff-gray limestones, with minute spherules of lime make up the upper 100 feet of this unit. Buff-gray and brown, granular limestones form the lower 50 to 60 feet of the Georgetown. The brown limestone near the base of the division is soft and slightly porous in places, and may have small showings of oil and gas.

Foraminifera
- *Globigerina washitensis* (Carsey)
- *Globigerina* sp.
- *Rotalia* sp.

Ostracods
- *Cytherella* sp.

Edwards formation. Hard, gray, crystalline limestone; medium-hard, gray and buff chalky limestone, with minute spherules of lime; dark-brown, shaly limestone; black, limy shales, and white, gray, brown and translucent anhydrite. The black limestone, black shale and anhydrite section make up the lower 300 feet of the formation. Buff and brownish-gray, dolomitic, slightly porous limestone occurs also in the lower part of the Edwards and usually produces salt-sulphur water and under favorable conditions oil and gas.

Foraminifera
- *Anomalina* sp.
- *Globigerina* cf. *cretacea* d'Orbigny
- *Globigerina* sp.
- *Gümbelina* sp. (?)
- *Robulus* sp. (?)
- *Rotalia* sp.
- *Spiroloculina* sp.

Ostracods
- Fragments, genus (?)

Comanche Peak and Walnut formations. These units of the Fredericksburg group have not been identified in the Maverick County section. If present they are assigned to either the Edwards or Glen Rose formations.

Glen Rose formation.—Hard, dark-gray, sub-crystalline limestones; hard and soft, grayish-white, tan and brown, dolomitic limestones; brown and black shaly limestones and black, calcareous shale. Accessory minerals include anhydrite, pyrite, translucent dolomite and some calcite. The occurrence of the anhydrite is not like the solid 400- to 500-foot zone of the Glen Rose in northern Louisiana. As thin beds and vein material it is well distributed through the Glen Rose and the lower part of the Edwards. There are at least eleven horizons of anhydrite in the Maverick County region. There are also several, honey-combed porous zones in the dolomitic limestone series of this formation. One in particular is associated with anhydrite and yields salt water, oil and gas.

Foraminifera
- Miliolidae, genus (?)
- *Massilina* sp.
- *Quinqueloculina* sp.
- *Spiroloculina* sp.
- *Orbitolina texana* Roemer
- *Orbitolina* cf. *whitneyi* Carsey

Ostracods
- *Bairdia* cf. *dorsoventra* Vanderpool
- *Bairdia* sp.
- *Bythocypris* cf. *rotunda* Vanderpool
- *Bythocypris* sp.
- *Cytheridea* cf. *trinitiensis* Vanderpoo
- *Cytherella* sp.
- *Paracypris* sp.

CONCLUSIONS

Discovery of a total thickness of more than 10,000 feet of Cretaceous beds in Maverick County, Texas, and study of the general lithologic and paleontologic nature of the section has led to a number of conclusions:

1. The early Cretaceous (Comanchean) sea invaded the Rio Grande embayment during the period of the oldest Trinity[2] (Aptian) and was not entirely withdrawn until after latest Navarro (Maestrichtian) time.

2. While minor oscillations of the shore line accounted for deposits of limestone, shale and sandstone, the prevailing movement was that of slow subsidence which permitted the accumulation of a great thickness of sediments.

3. From Glen Rose (Albian) time through the Taylor (Santonian) epoch, deposition was nearly continuous and consisted of alternating shallow-water marine limestones and shales.

4. During Campanian and Maestrichtian time marine sandstone, shale and thin limestone beds were laid down with an interval of essentially non-marine, low-land or marsh sediments including coal beds (Olmos). It is evident that a number of small stratigraphic interruptions with accompanying paleontologic breaks exist in the Navarro sequence in Maverick County.

5. The long time-ranges and overlapping of faunal species together with the gradations in lithology of the beds in this section make the problem of formation differentiation extremely difficult.

[2]The name Trinity is here used to refer to the oldest group of the Lower Cretaceous (Comanchean) in Texas. This division includes three formations, the Basement sands, Glen Rose and Paluxy in ascending order. (*Bull. Am. Assoc. Petrol. Geol.*, Vol. 12 (1928), p. 1071.).

AGE OF THE KREYENHAGEN SHALE IN CANTUA CREEK-PANOCHE CREEK DISTRICT, CALIFORNIA[1]

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Western Gulf Oil Company, Los Angeles, California

ABSTRACT

Evidence is presented to show that the upper part of the Kreyenhagen shale is late Eocene or early Oligocene in age, the nature of the foraminiferal fauna indicating early Oligocene.

One of the subjects selected for consideration at recent gatherings of geologists in California has been the so-called siliceous shale problem; that is, the origin, age and inter-relations of the white shale formations so extensively developed in the oil series of this state. The exchange of views has brought out much that is new, and, what is equally important, has served to point out to those interested, the course to be followed in further studies. Since several people are now engaged in this work, it seems appropriate to make available without delay certain data regarding fossil collections made recently in the Cantua Creek-Panoche Creek district.

For present purposes there is no occasion to set forth an account of the original application of the term Kreyenhagen as a formational name and its subsequent varied use, but it is sufficient to state that the name, as used here, is in the sense followed by Anderson and Pack[2] in the region north of Coalinga.

Throughout the Cantua Creek-Panoche Creek district the upper limit of the formation is sharply defined through being overlain unconformably by younger strata ranging in age from Miocene to late Pliocene. On Cantua Creek the beds are capped by a fossiliferous sandstone, the "Vaqueros" of Anderson and Pack, now regarded as Temblor; seventeen miles northwest the Temblor beds wedge out through overlap by gravelly sandstones of the Jacalitos-Etchegoin sequence and, in the same vicinity, these beds in turn are overlapped by still later Pliocene deposits which extend back onto the truncated edges of the Kreyenhagen strata.

[1]Published through courtesy of Western Gulf Oil Company, Los Angeles.

[2]Robert Anderson and Robert W. Pack, "Geology and Oil Resources of the West Border of the San Joaquin Valley North of Coalinga, California," *U. S. Geol. Survey Bull.* 603 (1915), pp. 49-50 and 76-77.

Fossils are only sparingly present in the Kreyenhagen but, in the course of the present work, richly foraminiferal layers were found and also occurrences of molluscan shells, the combined evidence of which it is proposed to set forth. The first collecting locality described is on Cantua Creek, at about the west edge of Sec. 34, T. 17 S., R. 14 E.; the second is nine miles northwest on Monocline Ridge near Arroyo Ciervo, Sec. 25, T. 16 S., R. 13 E.; and the third is seven miles still farther northwest along and near Tumey Gulch, Secs. 1 and 12, T. 16 S., R. 12 E.

CANTUA CREEK LOCALITY

Uppermost Kreyenhagen strata here consist of light gray, siliceous shale, the less weathered portion being of brownish, organic appearance and abounding in foraminifera. The presence of an unconformity at the top is demonstrated by excellent showings of *Pholas* borings where the highest shale strata crop out in the bed of Cantua Creek, in the SE. ¼, Sec. 34. For convenience in comparison with exposures at the other localities this is designated the "D" horizon. Dr. Paul Goudkoff, who has studied all material collected, submits the following list with comments:

FOSSIL LIST FROM "D" HORIZON, CANTUA CREEK

Bulimina sculptilis Cushman	Common
Cassidulina aff. *subglobosa* Brady	Rare
Cibicides hodgei Cushman and Schenck	Rather rare
Dentalina communis d'Orbigny	Rather rare
Eponides aff. *condoni* Cushman and Schenck	Common
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna	Rare
Lenticulina sp.	Rare
Plectofrondicularia packardi Cushman and Schenck	Common
Robulus cultratus Montfort (?)	Rather rare
Uvigerina cocoaensis Cushman	Rare

Regarding this fauna Dr. Goudkoff states that it closely resembles that from a horizon, supposedly the same, at the collecting locality on Tumey Gulch seventeen miles northwest; furthermore the resemblance is very close to a foraminiferal assemblage described by Cushman and Schenck[3] from the Bassendorf and Keasey shales of Oregon, differing chiefly in the absence of *Guttulina problema* d'Orbigny, *Sigmoidella elegantissima* (Parker and Jones), *Epistomina eocenica* Cushman and M. A. Hanna, and *Anomalina coalingensis* Cushman and G. D. Hanna.

[3]Joseph A. Cushman and Hubert G. Schenck, "Two Foraminiferal Faunules from the Oregon Tertiary," *Univ. Calif. Publ., Bull. Dept. Geol.*, Vol. 17 (1928), pp. 305-24.

LOCALITY ON MONOCLINE RIDGE NEAR ARROYO CIERVO, SEC. 25, T. 16 S., R. 13, E.

The upper third of the Kreyenhagen, as found here and along neighboring portions of Monocline Ridge, includes a prominent sandstone member persistent northwest beyond Tumey Gulch but not recognized with certainty in the exposures of lower Cantua Creek.

GENERALIZED SECTION, UPPER PART OF KREYENHAGEN

TEMBLOR "REEF" BEDS. Calcareous, fossiliferous, conglomeratic sandstone resting unconformably on the Kreyenhagen.

KREYENHAGEN.

"A" horizon. Chalky white shale with richly fossiliferous, calcareous layer at top, as seen along the old Ciervo Mountain road, Sec. 25, T. 16 S., R. 13 E.; abounding in specimens of "*Leda*" *washingtonensis* Weaver; the thickness of these beds is, at the maximum, 5 to 10 feet.

"B" horizon. White to light chocolate, diatomaceous shale, locally rich in specimens of thin-shelled pelecypods and foraminifera. This shale is several hundred feet thick along the central part of Monocline Ridge and thins northwestward, not being present at Tumey Gulch. "B" horizon is not sharply divisible from "A."

"C" horizon. Sandstone, thickness 400 feet or more in maximum development, thinning northwest and changing to shaly southeast; not present on Cantua Creek; texture medium coarse to silty, friable, and locally containing large, rounded ferruginous concretions; the basal portion persistently shows conglomeratic beds around 50 feet thickness, characterized by a matrix of coarse, calcareous sandstone, thickly shot with black chert pebbles of buckshot size, together with white shell fragments and occasional sharks' teeth. The contact with the underlying "D" beds is such as to denote an erosion surface with possible angular discordance.

"D" horizon. Shale, light chocolate to white, intersected by occasional sandstone dikes; uppermost portion rich in foraminifera. This shale with lithologic variations constitutes the great bulk of the Kreyenhagen formation, being 1,000 feet or more in thickness.

The molluscan fossils from horizons "A" and "B" were submitted to Dr. W. P. Woodring who makes the following comments.

HORIZON "A"—"*Leda*" *washingtonensis* Weaver, "*Macrocallista*" cf. *pittsburghensis* Dall, *Tellina?*

The "*Leda*" and "*Macrocallista*" are recorded by Professor Bruce Clark[4] from the upper part of the Kreyenhagen shale north of Coalinga. He correlated the beds, carrying them with the Lincoln horizon of Washington, which is considered of lower Oligocene age.

HORIZON "B"—*Acila* sp., "*Pecten*" cf. *peckhami* Gabb, *Thyasira* small species, "*Macrocallista*" small species.

I know of no Eocene species of *Thyasira* from the Pacific Coast. According to current nomenclature this material would be called Oligocene, but it may be upper Eocene.

[4] "The San Lorenzo Series of Middle California: A Stratigraphic and Paleontologic Study of the San Lorenzo Oligocene Series of the General Region of Mount Diablo, California," *Univ. Calif. Publ., Bull. Dept. Geol.*, Vol. 11 (1918), pp. 63-64, 99.

Material from horizon "B" containing microfossils was submitted to Dr. Goudkoff whose list follows.

HORIZON "B" FORAMINIFERA

Bulimina sculptilis Cushman	Rare
Dentalina communis d'Orbigny	Rare
Dentalina pauperata d'Orbigny	Rather rare
Eponides aff. *condoni* Cushman and Schenck	Very rare
Guttulina byramensis (Cushman)	Very rare
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna	Rare
Lenticulina sp.	Very rare
Plectofrondicularia packardi Cushman and Schenck	Very rare
Robulus cultratus Montfort	Rare
Robulus inornatus (d'Orbigny(?))	Very rare
Uvigerina cocoaensis Cushman	Abundant
Radiolaria	Common

TUMEY GULCH AND VICINITY, SECS. 1 AND 12, T. 16 S., R. 12 E.

On Tumey Gulch, Temblor sandstones rest unconformably on sandstones corresponding to "C" horizon of Arroyo Ciervo. At points a mile or so southeast, the white shales of "B" horizon begin to intervene. "C" sandstone has a thickness of somewhat more than 100 feet and everywhere shows a black pebble, buckshot-size, conglomerate with fossil fragments. "D" shale sampled at two places in this vicinity, contains abundant thin-shelled pectens ("*Pecten*" cf. *peckhami* Gabb) and a foraminiferal grouping closely resembling that of the Cantua Creek collection. Dr. Goudkoff's list with comments follows. He states that this assemblage is decidedly different from the California Miocene foraminifera content, and that every one of the species listed is identified with those described by Cushman and Schenck from the Bassendorf and Keasey shales of Oregon.

FOSSILS FROM "D" HORIZON

Bulimina sculptilis Cushman	Rare
Cassidulina aff. *subglobosa* Brady	Common
Dentalina consobrina d'Orbigny	Rare
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna	Common
Lagena sp.	Common

In conclusion, it appears that, so far as indicated by the molluscan fossils, the uppermost Kreyenhagen beds of the several localities described, with the possible exception of the "A" horizon, may be either early Oligocene or late Eocene. The evidence of the foraminifera definitely points to an age similar to that of the Bassendorf and Keasey shales of the Oregon Coast Range, which were tentatively assigned to the lower Oligocene by Cushman and Schenck.

THE GENUS *BOLIVINELLA* IN THE OLIGOCENE OF MISSISSIPPI

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ABSTRACT

Three new species and one new variety of the foraminiferal genus *Bolivinella* are described from the Oligocene of Mississippi.

INTRODUCTION

The genus *Bolivinella* includes a great variety of forms, nearly all of which at one time or another since 1865 have been referred to "*Texularia folium*" (Parker and Jones).

In the Tertiary of the Gulf Coast the first reference to this form was made by Cushman[1] in 1920, in describing the Byram marl fauna of Mississippi. At that time he referred a species to *Textularia folium* which he later described as *Bolivinella subpectinata* Cushman. Likewise, in making a check list of species that are present in the Red Bluff at Hiwannee, Mississippi, the present author confused another species with *Textularia folium*. This Red Bluff species is here described as *Bolivinella ornata* Howe, n. sp.

It was not until 1927 that the proper position of *Textularia folium* was recognized and that species was used by Cushman as the type of the new genus *Bolivinella*. The recognition that this form did not belong in the Textulariidae at once suggested that further study would reveal additional species and would materially shorten the range of the form referred to *T. folium*. This Cushman[2] undertook and he found and described four new species and one new variety belonging to *Bolivinella*.

This careful study made by Cushman influenced the writer to examine species of *Bolivinella* in the various members of the Oligocene of Mississippi and the study has resulted in finding three additional new species and one new variety. It has also revealed that these species are

[1]J. A. Cushman, "The Byram Calcareous Marl of Mississippi and Its Foraminifera," *Jour. Wash. Acad. Sci.*, Vol. 10 (1920), p. 199.

[2]J. A. Cushman, "The Genus *Bolivinella* and Its Species," *Contr. Cushman Lab. Foram. Research*, Vol. 5 (1929), p. 34.

apparently all of short range and hence should prove excellent guides in distinguishing members of the Vicksburg group.

DESCRIPTION OF SPECIES

FAMILY HETEROHELICIDAE CUSHMAN

GENUS BOLIVINELLA CUSHMAN, 1929

BOLIVINELLA SUBPECTINATA CUSHMAN

Plate 21, figure 1

Textularia folium CUSHMAN (not Parker and Jones), 1920, *Jour. Washington Acad Sci.*, Vol. 10 (1922), p. 199; *U. S. Geol. Survey Prof. Paper* 129-E, p. 90, pl. 14, fig. 3; 1923, *Prof. Paper* 133, p. 18.

Bolivinella subpectinata CUSHMAN (1929), *Contr. Cushman Lab. Foram. Research*, Vol. 5, p. 34, pl. 5, fig. 8.

Test small, roughly rhomboid, widest at the base of the last formed chambers, very much compressed, sides nearly flat; chambers numerous, strongly curved; sutures slightly limbate, strongly raised above the general surface of the test, confluent in a zig-zag line along the median line of the test, projecting somewhat at the peripheral margins forming a subpectinate edge; walls and sutures smooth. Length 0.50 mm.; breadth 0.40 mm.

It can be distinguished from the other species of the genus by the lack of a median ridge or channel and the subpectinate border with strongly raised, narrow sutures.

1. Number of chambers. Study of 118 individuals of this species from the Byram marl at Byram, Mississippi, and 36 from the Glendon(?) limestone at the top of the falls, Mint Spring Bayou, Vicksburg, Mississippi, indicates that the adult of this species has a maximum of 26 chambers. The form originally pictured by Cushman[3] has 21 chambers and is therefore not of maximum growth. The specimen used by him as a type has 24 chambers and is therefore typical.

2. Length. Careful measurements of 118 specimens of this species from the Byram marl at Byram, Mississippi, show that not a single

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EXPLANATION OF PLATE 21

FIG. 1.—*Bolivinella subpectinata* Cushman. From Byram Marl, Byram, Miss.

2a, 2b.—*Bolivinella subpectinata* Cushman, var. *interrupta* Howe, n. var. From Byram Marl, Byram, Miss.

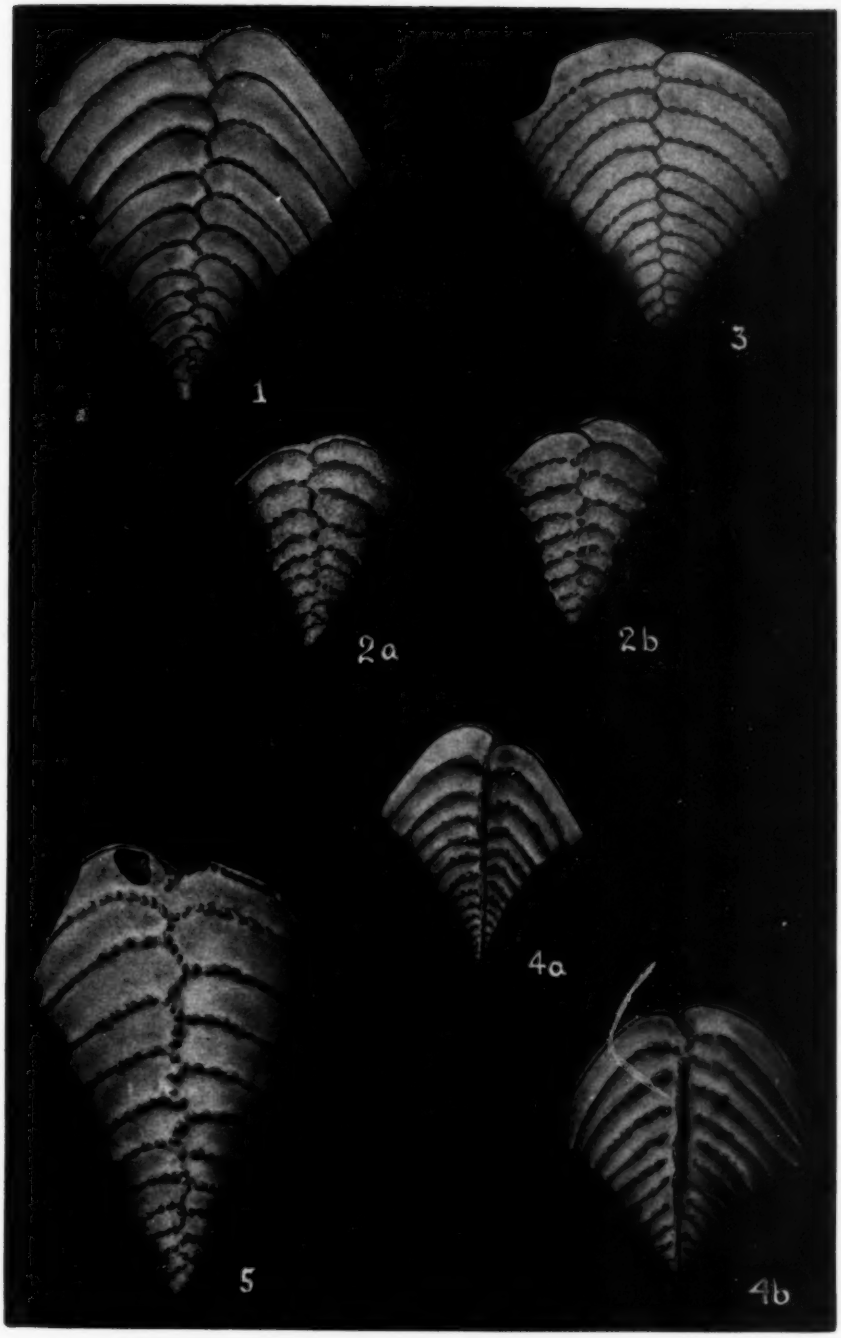
3.—*Bolivinella compressa* Howe, n. sp. From Byram Marl, Byram, Miss.

4a, 4b,—*Bolivinella rugosa* Howe, n. sp. From Red Bluff Clay, Hiwannee, Miss.

5.—*Bolivinella vicksburgensis* Howe, n. sp. From Glendon ? Limestone at top of falls, Mint Spring Bayou, Vicksburg, Miss.

All figured specimens are deposited in the Cushman Laboratory for Foraminiferal Research, Sharon, Mass. Co-types are deposited in the Museum of the Louisiana State University, Baton Rouge, Louisiana.

[3]J. A. Cushman, *U. S. Geol. Survey Prof. Paper 129-E.* (1922), pl. 14, fig. 3.



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specimen exceeds 0.41 mm. in length. The average length of specimens with 25 chambers is 0.39 mm. The average length of specimens with 24 chambers is 0.35 mm., and of those having 21 chambers is 0.31 mm.

3. Width. Study of the ratio of width to length in 61 unbroken specimens shows that in 20 cases the test is as wide as long and that in no case is the width less than 92 per cent of the length in adult individuals.

4. Apical angle. This term is here used for the angle made by the edges of the test where they come together at the initial chamber. In all of the unbroken specimens measured by the writer the smallest angle on an adult specimen is 72 degrees and the largest is 91 degrees. The average apical angle in the adults is 79 degrees, measured from the ends of the last chamber to the initial chamber. It should be noted that in the case of specimens from the Byram marl the angle on the first 10 to 14 chambers is frequently as low as 60 degrees; but this angle rapidly increases with the addition of each chamber until it becomes 72 to 91 degrees in the adult. Most of the specimens from the Glendon(?) limestone at the falls of Mint Spring Bayou, Vicksburg, Mississippi, seem to show a nearly constant apical angle between 75 and 90 degrees from the first few chambers to the last chamber.

5. Thickness. All of the specimens observed from the Byram marl appear to be thicker along the median line than at the margins. Most specimens have a thickness of about 0.06 mm. at the inner end of the last chambers and about 0.04 mm. at the outer ends of the chambers.

6. Sutures. There is great variation in the sutures of this species. However, the following observations appear to hold in all specimens examined: (a) the sutures are raised quite definitely above the surface of the test; (b) they are confluent and form a zig-zag line down the middle of the test instead of forming a raised ridge; and (c) they definitely project at the margins, forming a subpectinate border. The amount the sutures are raised above the surface of the test is quite variable. The amount they project at the margins is likewise quite variable. Similarly, the amount of their curvature is variable. However, in most cases they intersect the margin at an angle of about 80 degrees.

7. Range. This species is common in the Byram marl and is also moderately common in the Glendon(?) limestone at the falls of Mint Spring Bayou, Vicksburg, Mississippi. It has not been found in any of the lower portions of the Oligocene.

BOLIVINELLA SUBPECTINATA, VAR. INTERRUPTA HOWE N. SP.
Plate 21, figures 2a, 2b

This variety differs from *B. subpectinata* in that it is relatively much thicker, and is apparently as thick at the margins as at the center. The sutures are much more highly raised above the surface of the test; they project much more uniformly at the margins; and instead of being smooth and confluent, the sutures are divided by an irregular arrangement of interruptions at their inner ends so as to form an irregular series of nodes down the median portion of the test. The maximum number of chambers observed is 18; the average is 16. The apical angle varies from 50 to 60 degrees. Length, 0.26 mm.; width, 0.22 mm.; thickness, 0.06 mm. This variety is based on 14 specimens obtained from the Byram marl at Byram, Mississippi. It has not been observed elsewhere.

BOLIVINELLA COMPRESSA, HOWE, N. SP.
Plate 21, figure 3

Test small, widest at the base of the last-formed chamber, very compressed; being apparently of uniform thickness from one margin to the opposite margin; chambers numerous 25 to 28 in the adult; regularly curved; sutures slightly limbate, not raised above the surface of the test, but rather depressed and ornamented with numerous little rounded beads which rise slightly above the general flat surface of the test, confluent in a zig-zag line along the median line of the test, not generally projecting beyond the ends of the chambers; margin notched where each succeeding chamber is added; walls smooth and very thin. Length of type specimen: 0.31 mm.; width, 0.32 mm.; thickness 0.03 mm.

This species differs from *B. subpectinata* in being wider, more compressed and in lacking the raised sutures which characterize that species.

Description of this species is based on four specimens from the Byram marl at Byram, Mississippi. Not observed elsewhere.

BOLIVINELLA VICKSBURGENSIS HOWE, N. SP.
Plate 21, figure 5

Test small, elongate, widest at the outer edge of the last-formed chamber, compressed, but much thicker in the middle than at the edges; edges rounded and indented at or just above the suture lines; chambers smooth, gently curved down the middle of the test, the later ones slightly sigmoid; sutures confluent, limbate, forming a zig-zag line approximately flush with the surface of the chambers and ornamented with a regular series of raised beads. Length, 0.32 mm.; width, 0.20 mm.

This species is most closely related to *B. margaritacea* Cushman from the Miocene of Pont Gourguet, Saucats, near Bordeaux, France. It differs, however, in the regular beading of the sutures, and in the zig-zag arrangement of the sutures where they meet along the median line of the test.

This species is very common in the Glendon(?) limestone at the top of the falls at Mint Spring Bayou, Vicksburg, Mississippi. The description is based on 78 specimens. It has so far been observed only from this limestone bed.

BOLIVINELLA RUGOSA HOWE, N. SP.

Plate 21, figures 4a, 4b.

Bolivinella folium Howe, 1928, Jour. Pal., vol. 2, p. 174 (list).

Test small, compressed, broad and triangular in front view, the apertural end broadly convex, widest near the middle; chambers in two alternating series, only slightly curved; sutures limbate, very strongly raised above the general surface of the test, very irregular in their height and divided into a series of irregular raised nodes near the median portion of the test; the median line of the test marked by a pronounced raised ridge, which is separated from the last nodes of the sutures in most cases by a smooth area or channel, the summit of the ridge irregular in its elevation; wall smooth; periphery usually with blunt spines where the sutures project. Length, 0.33 mm.; width, 0.30 mm.

B. rugosa most closely resembles *B. folia* var. *ornata*, a living form from the coast of Australia, but is decidedly different in ornamentation, being by far the most strongly ornamented species of the genus yet noted. Description based on 38 individuals.

This species is exceedingly common in the Red Bluff, Oligocene, at the type locality at Hiwannee, Mississippi. It has not been observed in other members of the Oligocene.

THE GENUS *ORBITOIDES* IN AMERICA, WITH DESCRIPTION OF A NEW SPECIES FROM CUBA[1]

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ABSTRACT

The genus *Orbitoides* of Upper Cretaceous age is widely distributed in Eurasia but has been recorded only in Jamaica in the Western Hemisphere. A new species, *O. palmeri*, from a well near Havana, Cuba, is described here.

Recently, while at Scripps Institution of Oceanography, University of California, La Jolla, California, the writer was given by Mrs. Dorothy K. Palmer about 18 specimens of a species of *Orbitoides*, which were obtained by Dr. Robert H. Palmer from a depth of 950 feet in a well a short distance northwest of the village of Campo Florido, Havana Province, Cuba. Acknowledgment and thanks are here expressed to Dr. T. Wayland Vaughan for suggestions and criticism in the preparation of this note.

The genus *Orbitoides*, according to present information, is restricted to the Upper Cretaceous. It has long been known to occur in Europe, Arabia, India, and Tibet; but hitherto there has been only one previous mention of its occurrence in the Western Hemisphere. Matley (1929) records from the basal complex of Jamaica a species designated by A. Morley Davies as "an orbitoid foraminifera of Upper Cretaceous aspect, approaching *Orbitoides apiculata* Schlumberger." The specimens from Cuba are here described as a new species named *Orbitoides palmeri*.

GENUS ORBITOIDES D'ORBIGNY, 1847

Genolectotype, *Orbitoides media* (D'ARCHAIC)

Orbitoides D'ORBIGNY, *1847*, Geol. Soc. London, Quart. Jour., Vol. 4, p. 11; *1850*, Cours élément. Paléont., Vol. 2, p. 193, fig. 316.

Silvestrina PREVER, *1904*, Rev. Ital. Paleont., Vol. 10, p. 122, pl. 6, fig. 3.

Orbitella H. DOUVILLE, *1915*, Acad. Sci., C. R., Vol. 161, p. 666, figs. 5, 6; *1921*, Soc. géol. France Bull., 4th ser., Vol. 20, p. 214.

Test lenticular, more or less compressed, surface ornamented with vermicular pillars or radiating costae. Embryonic apparatus enveloped by a thick wall, normally quadrilocular, in some specimens trilocular or

[1]Published with permission of the Gulf Production Company.

bilocular. Equatorial chambers with a curved outer wall and converging lateral walls formed by the outer walls of the preceding annuli. Communication between the chambers by a few lateral stolons.

ORBITOIDES PALMERI GRAVELL, N. SP.
Plate 22, figures 1-10

Test small; form biconical, one side more rounded than the other; diameter up to 4 mm., average 2.5 mm.; thickness up to 3 mm., average 1.5 mm. Surface of test ornamented by costae formed by the distal ends of the pillars, which are of clear shell material and do not project appreciably above the general surface of the test. Costae originate at the apex, from which they radiate peripherally. They are vermicular and long, attaining a length of 1.0 mm. and a thickness of 200 μ. The costae near the periphery vary in outline as seen in plan from roughly circular, with a diameter of about 30 μ, to more or less curved ridges which may attain a length of 300 μ and a width of about 50 μ. The vermicular costae vary considerably in the degree of their development, being only slightly developed in some specimens.

Embryonic apparatus ellipsoidal, composed of four chambers in most specimens, apparently three in some specimens. The entire apparatus is embraced by a perforate, thick common-wall, perforations about 5 μ in diameter. Length of the apparatus, 450 to 530 μ; width, 360 to 400 μ; thickness of wall, about 60 μ. All of the specimens are of the megalospheric form.

The equatorial chambers in horizontal sections have curved outer walls. The inner walls of most chambers converge and are formed by the outer walls of the chambers of preceding annuli; the length of the transverse diameter exceeds that of the radial. Near the embryonic apparatus, the radial diameter ranges from 30 to 70 μ; and the tangential diameter from 80 to 120 μ. Communication between the chambers is by means of stoloniferous openings, each chamber communicating with the two adjacent in both the preceding and succeeding annulus. The walls are about 10 μ thick; roofs and floors cribriform perforate, the perforations about 6 μ in diameter.

In vertical sections, the equatorial chambers are about 80 μ tall near the embryonic chambers; they increase in height toward the periphery, and at a distance of 1.1 mm. from center attain a height of about 200 μ. Most of the chambers show on their proximal sides two large stoloniferous apertures, which range in diameter from 18 to 30 μ.

The lateral chambers are low and arched; not arranged in definite tiers; about 12 layers on each side of the equatorial layer; length of chamber spaces from 35 to 70 μ; height from 7 to 12 μ; roofs and floors perforate, from 12 to 35 μ thick. In the central part of test there are pillars of irregular width, those near the periphery smaller and more regular.

This species, in the features of its embryonic apparatus and of its equatorial and lateral chambers, closely resembles *Orbitoides media* (d'Archaic) from the Upper Cretaceous (Maestrichtian) at Royan, on the Gironde, France. It differs, however, in the character of the surface ornamentation, *O. media* being entirely covered with vermicular radially arranged costae.

Locality and geologic horizon. Well drilled by Mr. Sage, a short distance northwest of the village of Campo Florido, Havana Province, Cuba; depth 950 feet; Upper Cretaceous. Material obtained by Dr. Robert H. Palmer.

Types. Cotypes, three uncut specimens, and three thin sections deposited in U. S. National Museum. Paratypes, Scripps Institution of Oceanography.

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Vaughan, T. Wayland, *Orbitoides*, in Cushman's *Foraminifera. their classification and economic use, Cushman Lab. Foram. Research*, Spec. Publ. No. 1 (1928), p. 337, pl. 57, fig. 4; pl. 58, figs. 1-6.

EXPLANATION OF PLATE 22

FIGS. 1-10.—*Orbitoides palmeri* Gravell, n. sp. 1-3, surface views × 10; 4, same as 2, × 5; 5, horizontal section, × 28; 6, enlarged view of embryonic apparatus × 28; 7, same × 74; 8, same as 5, × 78; 9, enlarged view of equatorial chambers showing chamber communications, × 74; 10, vertical section, × 28.

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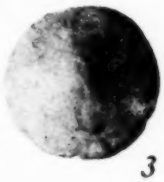

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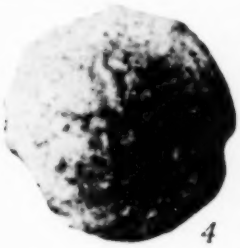

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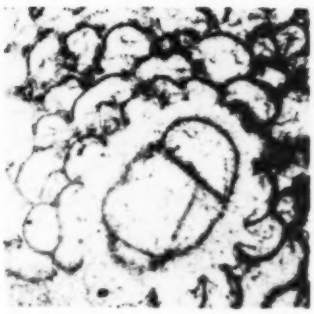

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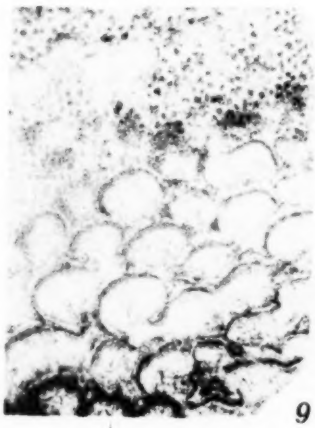

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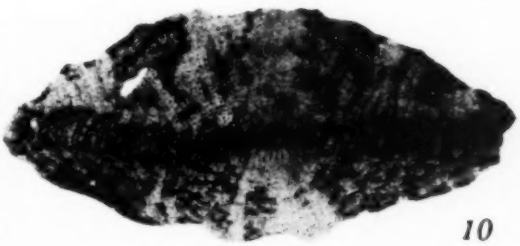

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EOCENE FORAMINIFERA FROM MEXICO

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ABSTRACT

The guide foraminifera of the Eocene deposits of the Tampico embayment, Mexico, are indicated with notes on their character and range. Special consideration is given to the Aragon fossils, of upper Lower Eocene age. Nine new species and four new varieties of foraminifera are described.

INTRODUCTION

The geological formations of the Tampico embayment, Mexico, mentioned in this paper are as follows: Alazan (Lower Oligocene), Chapapote (Upper Eocene), Guayabal (Middle Eocene), Aragon and Chicontepec (Lower Eocene), and Velasco (Upper Cretaceous).

The more common species of foraminifera found in the Chapapote and Guayabal formations have been described by Cushman and Cole.[1] The term Aragon is here introduced for beds immediately underlying the Guayabal, which contain a fauna described in this paper for the first time. The foraminiferal faunas of these three formations are distinct and afford an excellent illustration of the use of these microfossils in stratigraphy. The species of most value for recognition of each division are discussed below and their distribution is shown in a table.[2]

CHAPAPOTE FORMATION

The stratigraphic range of the more common Chapapote and Guayabal foraminiferal species has been worked out chiefly in oil-wells from Alamo northwest to Cerro Azul, a distance of about 32 kilometers, and also from surface outcrops in the haciendas of Horcones, Cerro Viejo and Tamatoco (Fig. 1). References to the more important Chapapote guide species are given below. These species do not range up into the Lower Oligocene (Alazan), except in certain localities where there is a

[1] W. S. Cole, "A Foraminiferal Fauna from the Guayabal Formation in Mexico," *Bull. Am. Pal.*, Vol. 14 (1927), No. 51; "A Foraminiferal Fauna from the Chapapote Formation in Mexico," *Idem.* (1928), No. 53.

[2] The writer is indebted to the Mexican Eagle Oil Company for generous permission for publication. The types of the species will be deposited in Dr. Cushman's collection.

disconformity at the base of the Oligocene and derived Eocene foraminifera are found in the basal 50 feet or so of the Oligocene. These last conditions are found in parts of the Buenavista river valley and notably at and near the Alazan type locality, from where mollusca referred to Vicksburg have been described by Cooke.[3] Generally the Oligocene-Eocene contact is sharp and may be distinguished readily with the aid of the foraminifera.

TABLE SHOWING RANGE OF THE MORE IMPORTANT GUIDE SPECIES FOR THE CHAPAPOTE, GUAYABAL AND ARAGON FORMATIONS.[a]

Species	*Chapapote*	*Guayabal*	*Aragon*
**Hantkenina alabamensis* Cushman	c		
Textularia eocaena (Gümbel) Cole	f		
Hantkenina brevispina Cushman	c	r	
**Anomalina dorri* Cole	c	r	
Globigerina inflata d'Orbigny	c	f	
Globigerina mexicana Cushman	c	f	
Eponides cerroazulensis (Cole)	f	r	
Anomalina umbonata Cushman	r	c	
**Rotaliatina mexicana* Cushman	c	r	
Hantkenina longispina Cushman		c	r
Hantkenina mexicana Cushman		f	f
Bulimina semicostata Nuttall, n. sp.	f	f	f
Eponides trümpyi Nuttall, n. sp.	f	r	f
Amphistegina mexicana Cole			
**Cristellaria mexicana* Cushman		c	
Discocyclina perpusilla Vaughan			
Frondicularia interrupta Karrer			
**Nodosaria mexicana* Cushman		c	
Operculina cushmani Cole			
**Eponides guayabalensis* Cole		c	
Eponides mexicana (Cushman)			
Ceratobulimina eximia (Rzehak)			
Textularia zapotensis Cole			
Globigerina topilensis Cushman			
**Globorotalia spinulosa* Cushman		c	f
Globorotalia crassata (Cushman)			
Anomalina dorri var. *aragonensis* Nuttall, n. var.			
Textularia aragonensis Nuttall, n. sp.			
**Cornuspira polygyra* Reuss			
Cristellaria asperuliformis Nuttall, n. sp.			c
Globigerina cretacea d'Orbigny			
Globigerina pseudobulloides Plummer			
Glomospira charoides (Jones and Parker)			
**Hantkenina mexicana* var. *aragonensis* Nuttall, n. var.			c
**Hastigerinella eocanica* var. *aragonensis* Nuttall, n. var.			c
**Globorotalia aragonensis* Nuttall, n. sp.			c
Vulvulina pectinata Hantken var. *mexicana* Nuttall, n. var.			

[a] *Explanation.* Stratigraphic range is shown by solid horizontal line Relative abundance of species is indicated by (c) common, (f) frequent, (r) rare. (*) Indicates most important guide species.

[3] C. W. Cooke, *Proc. U. S. Nat. Mus.*, Vol. 73 (1928), Art. 10.

The term Tantoyuca has been used as a formational name in papers by Cushman and Cole. The type locality is in the vicinity of Tantoyuca, in particular to the east of it on the Tantoyuca-Chopopo road, towards the Tecomate stream. The writer is in agreement with the view expressed in Cole's paper that the type Tantoyuca is probably a near-shore facies of the Chapapote and both may be correlated as being Upper Eocene (Jackson) in age. The fauna of the Tantoyuca requires special study and is not dealt with in this paper. These beds contain numerous species of foraminifera recorded both from the Chapapote and Guayabal, as well as others restricted to the formation. Of particular interest is the

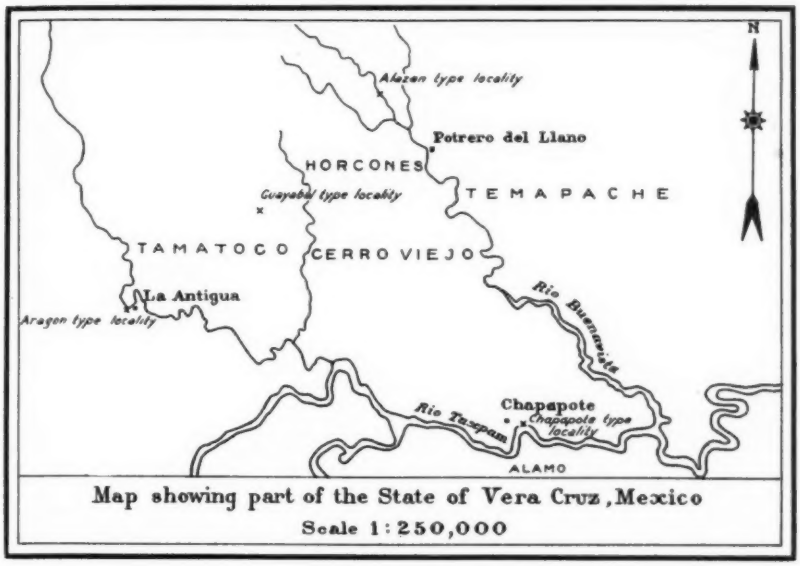

Figure 1

occurrence of *Lepidocyclina ocalana* Cushman, *L. ocalana* var. *subdecorata* Cushman and *Cardita* aff. *planicosta* (Lam.). The term Tantoyuca has often been loosely employed by geologists in Tampico, and beds of Guayabal age have frequently been included under this formation.

GUAYABAL FORAMINIFERA

The following species are of most value for distinguishing the Chapapote:

TEXTULARIA EOCAENA (GÜMBEL)

Textularia eocaena (Gümbel). COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 6, Pl. 3, fig. 7.

HANTKENINA ALABAMENSIS CUSHMAN

Hantkenina alabamensis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 7, Pl. 1, fig. 11; *1927*, Jour. Pal., Vol. 1, p. 160, Pl. 25, fig. 17; COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 11.

HANTKENINA BREVISPINA CUSHMAN

Hantkenina brevispina CUSHMAN, *1924*, Proc. U. S. Nat. Mus., Vol. 66, Art. 30, p. 2, Pl. 2, fig. 3; *1927*, Jour. Pal., Vol. 1, p. 160, Pl. 26, fig. 1. COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 12.

HANTKENINA LONGISPINA CUSHMAN

See page 284.

BULIMINA SEMICOSTATA NUTTALL, N. SP.

See page 285.

ROTALIATINA MEXICANA CUSHMAN

Rotaliatina mexicana CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 4., Pl. 1, fig. 1. COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 15, Pl. 3, figs. 3, 4.

EPONIDES CERROAZULENSIS (COLE)

Globigerina cerro-azulensis COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 17, Pl. 1, figs. 11-13.

EPONIDES TRUMPYI NUTTALL, N. SP.

See page 287.

GLOBIGERINA INFLATA D'ORBIGNY

Globigerina inflata D'ORBIGNY, *1839*, Hist. Nat. Canaries. Foram., p. 134, Pl. 2, figs. 7-9; BRADY, *1884*, Rept. Voyage *Challenger* Zool., Vol. 9, p. 601, Pl. 79, figs. 8-10; COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 33, Pl. 4, fig. 19; *1928*, Bull. Am. Pal., Vol. 19, No. 53, p. 17.

GLOBIGERINA MEXICANA CUSHMAN

Globigerina mexicana CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 6, Pl. 1, fig. 8; *1927*, Jour. Pal., Vol. 1, p. 168, Pl. 26, figs. 16, 17; COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 18, Pl. 2, fig. 11.

ANOMALINA DORRI COLE

Anomalina dorri COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 18, Pl. 3, figs. 1, 2. A closely related form is described below from the Aragon, see page 290.

ANOMALINA UMBONATA CUSHMAN

Anomalina umbonata CUSHMAN, *1925*, Bull. Am. Assn. Petrol. Geol., Vol. 9, p. 300, Pl. 7, figs. 5, 6; *1927*, Jour. Pal., Vol. 1, p. 170, Pl. 27, figs. 10, 11; COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 35; *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 19.

GUAYABAL FORMATION

A marked change in facies occurs between the Chapapote and Guayabal. The former contains a very rich fauna, *Globigerina* often forming the majority of the washed sample. In the Guayabal shallower water conditions prevailed, *Globigerina* becomes much less common and larger forms like *Operculina*, *Amphistegina* and *Discocyclina* are present. Lithologically the Chapapote is a practically pure marl and the foraminifera are brilliant white. The Guayabal shale beds have thin sand partings and the foraminifera are usually stained a light brown by iron.

The term Tempoal was introduced by W. A. Ver Wiebe[4] for shale exposed in the river at the town of Tempoal. Cole pointed out that the foraminiferal fauna of the Tempoal is very similar to that of the Guayabal. The writer has also examined material from this locality and regards the type Tempoal as constituting probably the lower part of the Guayabal. There appears to be no reliable lithological or paleontological means by which it is possible to separate the type locality Tempoal from the Guayabal, so that the former name appears superfluous. The maximum thickness observed for the Guayabal in the Tampico embayment has been 3,000 feet, these beds being considered as Middle Eocene in age.

GUAYABAL FORAMINIFERA

The more important species that serve for the recognition of this formation are the following.

TEXTULARIA ZAPOTENSIS COLE

Textularia mexicana COLE (not Cushman), *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 11, Pl. 5, fig. 5.

Textularia zapotensis COLE, *May 20th, 1929*, Corrigenda slip to same publication. This second name was proposed, as the first was preoccupied.

HANTKENINA MEXICANA CUSHMAN

See page 284.

CRISTELLARIA MEXICANA CUSHMAN

Cristellaria mexicana CUSHMAN, *1925*, Bull. Am. Assn. Petrol. Geol., Vol. 9, p. 299, Pl. 7, figs. 1, 2.

Robulus mexicanus (CUSHMAN), *1927*, Jour. Pal., Vol. 1, p. 151, Pl. 23, fig. 9 (in error given as fig. 8); COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 18, Pl. 1, fig. 20.

[4]Am. Jour. Sci., (5), Vol. 8 (1924), p. 486.

CRISTELLARIA MEXICANA VAR. NUDICOSTATA (CUSHMAN AND HANNA)

Robulus mexicanus var. *nudicostatus* CUSHMAN AND HANNA, *1927*, Proc. Cal. Acad. Sci., Vol. 16, No. 8, p. 216, Pl. 14, fig. 2; COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 19. This variety always occurs associated with *C. mexicana*.

NODOSARIA MEXICANA CUSHMAN

Nodosaria mexicana CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 5, Pl. 1, figs. 3, 4; *1927*, Jour. Pal., Vol. 1, p. 155, Pl. 24, figs. 15, 16; COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 16, Pl. 3, figs. 3, 4.

FRONDICULARIA INTERRUPTA KARRER

Frondicularia interrupta KARRER, *1877*, Abhl. K. K. Geol. Reichs., Vol. 9, p. 380, Pl. 16, fig. 27.
Frondicularia sp., COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 24, Pl. 2, fig. 10.

OPERCULINA CUSHMANI COLE

Operculina cushmani COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 23, Pl. 2, fig. 14.

EPONIDES GUAYABALENSIS COLE

Eponides guayabalensis COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 29, Pl. 2, figs. 18-20; CUSHMAN, *1929*, Jour. Pal., Vol. 3, p. 180, Pl. 23, fig. 6; WEINZIERL AND APPLIN, *1929*, Jour. Pal., Vol. 3, p. 394, Pl. 42, figs. 1a-c.
Eponides patelliformis STADNICHENKO, *1927*, Jour. Pal., Vol. 1, p. 232, Pl. 38, figs. 6-8.

This species, which is common in the Guayabal, is recorded from the Claiborne (Middle Eocene) of Texas.

EPONIDES MEXICANA (CUSHMAN)

Pulvinulina mexicana CUSHMAN, *1925*, Bull. Am. Assn. Petrol. Geol., Vol. 9, p. 300, Pl. 7, figs. 7, 8.
Eponides mexicana (CUSHMAN), *1927*, Jour. Pal., Vol. 1, p. 165, Pl. 26, figs. 6, 7. COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 29, Pl. 2, figs. 6-8.

GLOBOROTALIA CRASSATA (CUSHMAN)

See page 288.

GLOBOROTALIA SPINULOSA CUSHMAN

See page 288.

PLANORBULINA (PLANORBULINELLA) GUAYABALENSIS NUTTALL, N. SP.
Plate 25, Figures 15-17

Test lenticular, compressed, equilateral. Surface of chambers smooth, sutures limbate, raised above the chamber surfaces and all clearly visible externally. An equatorial section shows the first chamber to be circular and the earlier portion to be coiled with one large whorl, after which the chambers are arranged concentrically with adjacent

series of chambers alternating. There are two apertures, one on each side of each chamber, the walls being finely perforate.

This species differs from *P. larvata* Parker and Jones in having a different surface ornamentation and in the larger coiled portion. The maximum observed diameter is 2 mm., and the thickness about 0.2 mm., but the periphery was broken in the specimens examined.

AMPHISTEGINA MEXICANA COLE

Amphistegina mexicana COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 31, Pl. 2, fig. 13.

This species differs from *A. lessoni* in the much larger number and straighter sutures.

CERATOBULIMINA EXIMIA (RZEHAK)

Pulvinulina eximia RZEHAK, *1888*, Ann. K. K. Hofmuseums, Wein, Vol. 3, pt. 3, p. 263, Pl. 11, fig. 7.
Rotalia dorri COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 29, Pl. 4, figs. 5, 6.
Ceratobulimina eximia COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 20; CUSHMAN, *1929*, Jour. Pal., Vol. 3, p. 182, Pl. 24, fig. 3.

This species occurs frequently in the Guayabal, especially in the lower part. It has also been recorded from the Claiborne of Texas.

GLOBIGERINA TOPILENSIS CUSHMAN

See page 289.

DISCOCYCLINA PERPUSILLA VAUGHAN

Discocyclina perpusilla VAUGHAN, *1929*, Proc. U. S. Nat. Mus., Vol. 76, Art. 3, p. 9, Pl. 2, figs. 3-5.
Discocyclina clarki COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 51, p. 36, Pl. 2, fig. 31 (not *Orthophragmina clarki* Cushman).

DISCOCYCLINA CUSHMANI VAUGHAN

Discocyclina cushmani VAUGHAN, *1929*, Proc. U. S. Nat. Mus., Vol. 76, Art. 3, p. 11, Pl. 3, figs. 1-4.

LEPIDOCYCLINA (POLYLEPIDINA) PROTEIFORMIS VAUGHAN

Lepidocyclina (Polylepidina) proteiformis VAUGHAN, *1924*, Bull. Geol. Soc. Am., Vol. 35, p. 810, Pl. 32, figs. 1-7, text figs. 6 a-c; *1929*, Proc. Nat. Ac. Sci., Vol. 15, No. 3, p. 290, Pl., fig. 8.

ARAGON FORMATION

The beds immediately underlying the Guayabal, as defined above, contain a distinct foraminiferal fauna. These strata were mentioned by

Cole[5] as an unnamed formation, consisting of about 200 feet of shale. The average thickness of the formation in the Tampico embayment is about 500 feet, while it may be considerably thinner in wells between Cerro Azul and Alamo. These beds are designated as the Aragon formation and the type locality defined as shale outcrops in the Rio de La Puerta, immediately west of La Antigua village, which is situated about 19 kilometers west of Potrero del Llano. The Aragon usually overlies shale with the Velasco fauna described by Cushman,[6] while towards the mountain front it rests upon the Chicontepec formation. It differs from the Guayabal in being of deeper water facies, the former resembling the Chapapote by its abundance of *Globigerina*, which are however of different species. The Aragon is of Lower Eocene age and contains several species also present in the Midway of Texas.

[5]W. S. Cole, Bull. Am. Pal., Vol. 14 (1928), No. 51, p. 9.

[6]J. A. Cushman, Bull. Am. Assn. Petrol. Geol., Vol. 10 (1926), p. 581.

EXPLANATION OF PLATE 23

FIGS. 1.—*Glomospira charoides* (Jones and Parker). × 40. Arroyo La Laja, 380 m. S. 77° W. of La Antigua-Potrero del Llano road crossing.

2, 3.—*Haplophragmoides acutidorsatum* (Hantken) × 20. La Antigua, Rio La Puerta.

4.—*Trochammina irregularis* White. × 20. Arroyo La Laja, 2830 m. S. 70° W. of La Antigua crossing.

5.—*Textularia agglutinans* d'Orbigny. × 20. La Antigua, Rio La Puerta.

6.—*Textularia aragonensis* Nuttall, n. sp. × 40. 1850 m. N. 85° W. of El Tule.

7.—*Vulvulina pectinata* var. *mexicana* Nuttall, n. var. × 20. Rio La Puerta, 200 m. upstream from La Antigua crossing.

8.—*Verneuilina triquetra* (Munster). × 20. Arroyo La Laja, 720 m. S. 70° W. of La Antigua crossing.

9, 10.—*Cristellaria asperuliformis* sp. nov. × 20. Fig. 9. Holotype, Arroyo Pedernales, 4000 m. N. 2° E. of Camaitlan. Fig. 10. 1200 m. N. 60° W. of La Antigua crossing.

11, 14.—*Nonionina boueana* d'Orbigny. × 40, Fig. 11. Same locality as Fig. 7. Fig. 14, 1670 m. N. 70° W. of La Antigua crossing.

12.—*Bulimina elegans* d'Orbigny. × 40. Same locality as Fig. 7.

13, 17.—*Hantkenina mexicana* Cushman × 40. Arroyo Puentitla, 2600 m. N. 73° E. of El Tule.

15, 16.—*Bulimina semicostata* Nuttall, n. sp. × 40. Same locality as Fig. 8

18.—*Cornuspira polygyra* Reuss × 20. Same locality as Fig. 8.

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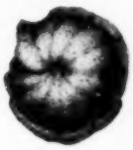

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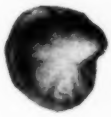

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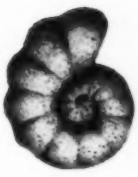

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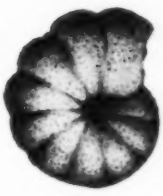

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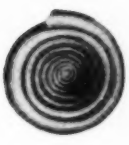

18

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ARAGON FORAMINIFERA

FAMILY AMMODISCIDAE

GLOMOSPIRA CHAROIDES (JONES AND PARKER)

Plate 23, figure 1

Trochammina charoides JONES AND PARKER, *1862*, Intro. Foram., p. 141, Pl. 11, fig. 3.
Ammodiscus charoides BRADY, *1884*, Rep. Voy. *Challenger*, Zool., Vol. 9, p. 334., Pl. 38, figs. 10-16.

The species, which is fairly common in the Aragon, appears to be the same as the living form. In the Tampico embayment this species has not been observed in younger beds.

FAMILY LITUOLIDAE

HAPLOPHRAGMOIDES ACUTICOSTATUM (HANTKEN)

Plate 23, figures 2, 3

Haplophragmium acuticostatum HANTKEN, *1875*, Mitth. Jahrb. K. Ungar. Geol. Anstalt, Vol. 4, p. 12, Pl. 1, fig. 1; ANDREAE, *1884*, Abh. Geol. Specialkarte Elsass-Lothr., Vol. 2, p. 197, Pl. 7, fig. 5.

This species occurs sparingly in the Aragon, while a very closely related form has been observed in the lower part of the Guayabal.

FAMILY TROCHAMMINIDAE

TROCHAMMINA IRREGULARIS WHITE

Plate 23, figure 4

Haplophragmium acervulata FRIEDBERG (not Grzybowski), *1902*, Abh. Akad. Wiss. Krakau, Vol. 41, p. 638, Pl. 1, fig. 9.
Trochammina irregularis WHITE, *1928*, Jour. Pal., Vol. 2, No. 4, p. 307, Pl. 42, fig. 1.

The chambers are crushed and somewhat variable in number. This form has been observed in the Chapapote, Aragon and Chicontepec, while White records it from the Velasco.

FAMILY TEXTULARIDAE

TEXTULARIA AGGLUTINANS D'ORBIGNY

Plate 23, figure 5

Textularia agglutinans D'ORBIGNY, *1839*, in De la Sagra, Hist. Phisiq. etc. Cuba. Foram., p. 144, Pl. 1, figs. 17, 18, 32-34.

This species, which has been observed fossil in the Miocene, Oligocene and Eocene of the United States, is present in the Aragon.

TEXTULARIA GOESII CUSHMAN

Textularia goesii CUSHMAN, *1911*, U. S. Nat. Mus., Bull. 71, pt. 2, p. 15.
Textularia trochus BRADY (not d'Orbigny), *1884*, Rept. Voy. *Challenger*, Zool., Vol. 9, Pl. 43, fig. 17; Pl. 44, figs. 1-3.

This species, which is present in the Alazan and Chapapote, has also been observed in the Aragon and Chicontepec.

TEXTULARIA ARAGONENSIS NUTTALL, N. SP.
Plate 23, figure 6

Test very compressed, suboval, slightly longer than broad, widest portion about at the center. Initial end tapered, apertural end broadly rounded. Sides only slightly convex, the thickness near the periphery being only a little greater than at the center. Chambers about three times as long as wide, ornamented with thin limbate sutures from which fine raised projections extend a short distance backwards on the chamber surfaces. Aperture a narrow transverse slit at the base of the last chamber. Average length 0.4 mm.

This species resembles *T. velascoensis* Cushman[7] from which it may be distinguished by its much more compressed form and the somewhat less ornate sutures. Cushman[8] referred his species to *Bolivinoides*, while White[9] placed it under *Gümbelina*. Both species depart much from the original definition of these genera and seem best retained under *Textularia*, though they are peculiar for the genus. The above species has so far only been observed sparingly in the Aragon formation.

VULVULINA PECTINATA VAR. MEXICANA NUTTALL, N. VAR.
Plate 23, figure 7

Vulvulina pectinata HANTKEN, var., *1875*, Mitth. Jahrb. K. Ungar. Geol. Anstalt, Vol. 4, p. 68, Pl. 7, fig. 10.

Test compressed, central portion inflated, border narrow, each chamber with a thin triangular projecting flange. Sutures narrow, depressed, showing the chambers to be biserially arranged except for a terminal uniserial chamber. This variety differs from the specimen figured by Hantken in being proportionally shorter and ending uniserially. Average length 1 mm. This species is frequent only in the Aragon.

[7]J. A. Cushman, Bull. Am. Assn. Petrol. Geol., Vol. 10 (1926), No. 6, p. 584.

[8]J. A. Cushman, Jour. Pal., Vol. 1 (1927), p. 159.

[9]T. M. White, Jour. Pal., Vol. 3 (1929), p. 39.

FAMILY VERNEUILINIDAE

VERNEUILINA TRIQUETRA (MÜNSTER)

Plate 23, figure 8

Textularia triquetra Münster, RÖMER, *1838*, Neues Jahrb., p. 384, Pl. 3, fig. 19.
Verneuilina triquetra FRANKE, *1928*, Abh. Preuss. Geol. Land. N. F., Vol. 3, p. 136, Pl. 12, fig. 13.

One of the features which distinguishes this species from closely related forms is the great width of the test for a major part of its length. This species, found rarely in the Aragon, has been recorded from the Cretaceous and older Tertiary of Europe, while the living form figured by Brady is probably distinct.

GAUDRYINA BRADYI CUSHMAN

Gaudryina bradyi CUSHMAN, *1911*, U. S. Nat. Mus., Bull. 71, pt. 2, p. 67, fig. 107.
Gaudryina pupoides d'Orbigny, BRADY, *1884*, Rep. Voy. *Challenger*, Zool. Vol. 9, p. 378, Pl. 46, figs. 1-4.
Textularia chapapotensis COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 6, Pl. 2, fig. 9.

This species has a wide range in the Tertiary of the Tampico embayment.

GAUDRYINA AFF. GAUDRYINOIDES (FORNASINI)

Clavulina gaudryinoides FORNASINI, *1885*, Boll. Soc. Geol. Ital., Vol. 4, p. 106, Pl. 6, figs. 3-9.
Gaudryina gaudryinoides COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 13, Pl. 2, fig. 30.

A short *Gaudryina* with a small oval aperture situated a short distance above the base of the last chamber is found in the Aragon. The specimens are all less elongate than Fornasini's original figures, but appear to be the same as the species identified by Cole from the Guayabal.

FAMILY OPHTHALMIDIIDAE

CORNUSPIRA POLYGYRA REUSS

Plate 23, figure 18

Cornuspira polygyra REUSS, *1864*, Sitz. Ak. Wiss. Wien, Vol. 48, (1) p. 39, Pl. 1, fig. 1.
Cornuspira hornesi KARRER, *1866*, Sitz. Ak. Wiss. Wien, Vol. 52, (1) p. 495, Pl. fig. 10.

This simple foraminifera represents a very close and multicoiled thin *Cornuspira* which has been recorded from the Lower Tertiary and Upper Cretaceous of Europe. It is common in the Aragon and ranges down into the Chicontepec and Velasco, while other species of this genus, which are rarely found in younger beds of the Tampico embayment, are more loosely coiled.

Family LAGENIDAE

CRISTELLARIA CONVERGENS Bornemann

Cristellaria convergens Bornemann, *1855*, Zeitschr. Deutsch. Geol. Ges., Vol. 7, p. 327, Pl. 13, figs. 16, 17; Cushman, *1927*, Jour. Pal., Vol. 1, p. 152, Pl. 23, fig. 12; Cole, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 8, Pl. 1, figs. 4, 5.

Typical specimens of this species occur in the Aragon. It has been observed to range up into the Alazan.

CRISTELLARIA CREPIDULA (Fichtel and Moll)

Nautilus crepidula Fichtel and Moll, *1803*, Test. Micr., p. 107, Pl. 19, figs. g-i.

This species, which has been observed in the Alazan, Chapapote and Aragon, has also been recorded by Cushman and White[10] from the Velasco.

CRISTELLARIA ROTULATA (Lamarck)

Lenticulites rotulata Lamarck, *1804*, Ann. Mus., Vol. 5, p. 188; *1806*, Vol. 8, Pl. 62, fig. 11.

This cosmopolitan species, which is recorded as ranging from the Cretaceous to the present day, is found in the Aragon.

CRISTELLARIA CULTRATA (Montfort)

Robulus cultratus Montfort, *1808*, Conch. Syst., Vol. 1, p. 215, 54th genre.

Varietal forms of this well known species occur in the Aragon. It also has a wide vertical range in the sediments of the Tampico embayment.

CRISTELLARIA ASPERULIFORMIS Nuttall, n. sp.

Plate 23, figures 9, 10

Test with earlier portion close-coiled, later portion uncoiled, compressed, especially in the earlier portion. Chambers distinct, separated by elevated limbate sutures, which bear fine tubercles that are variable in number and become less pronounced or absent in the last chambers. Aperture radial, terminal. Periphery sharp, in most specimens with a thin narrow keel. Average length 1.5 mm.

This species, which is frequent in the Aragon, is practically confined to this formation. It presents a fair range of variation in its external ornamentation. Of described species it resembles *C. asperula* Gümbel. from the Eocene of the Alps[11] which is, however, much less compressed, particularly in the earlier portion. It also bears affinities to *C. sub-*

[10] T. M. White, Jour. Pal., Vol. 2 (1928), p. 202.

[11] Abh. K. Bayer. Ak. Wiss., Vol. 10 (1870), Pl. 1, fig. 65.

aculeata var. *tuberculata* Plummer from the Midway of Texas.[12] It is distinguished from *C. mexicana* by having more chambers, more tubercles on the sutures, the initial part much more compressed and the edge sharper.

MARGINULINA GLABRA D'ORBIGNY

Marginulina glabra D'ORBIGNY, *1826*, Ann. Sci. Nat., Vol. 7, p. 259, No. 6, Modèle No. 55.

This well known species has been observed in the Aragon and is also present in the Alazan.

NODOSARIA COMMUNIS (D'ORBIGNY)

Dentalina communis D'ORBIGNY, *1826*, Ann. Sci. Nat., Vol. 7, p. 254, No. 35.

This species has been observed in the Alazan, Guayabal and Aragon.

NODOSARIA VERTEBRALIS (BATSCH)

The specimens are similar to specimens figured by Brady.[13]

NODOSARIA GRANTI PLUMMER

Nodosaria granti PLUMMER, *1926*, Univ. Texas Bull. 2644, p. 83, Pl. 5, fig. 9.

A few rare specimens assigned to this species described from the Midway occur in the Aragon.

NODOSARIA LONGISCATA D'ORBIGNY

Nodosaria longiscata D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 32, Pl. 1, figs. 10-12.

This species, which is present in the Aragon, ranges up into the Meson.

LAGENA ORBIGNYANA (SEGUENZA)

Fissurina orbignyana SEGUENZA, *1862*, Foram. Montal. Miocen. Messina, p. 66, Pl. 2, figs. 25, 26.

Rare specimens of this species occur in the Aragon.

[12]Univ. Texas Bull. 2644 (1926), p. 101.

[13]Rep. Voy. *Challenger*, Zool., Vol. 9 (1884), Pl. 64, figs. 11-14.

Family NONIONIDAE

NONIONINA BOUEANA d'Orbigny

Plate 23, figures 11, 14

Nonionina boueana d'Orbigny, *1846*, Foram. Foss. Vienne, p. 108, Pl. 5, figs. 11, 12. Reuss, *1862*, Bull. Ac. Roy. Belg., Ser. 2, Vol. 15, p. 156, Pl. 3, figs. 47, 48; Brady, *1884*, Rep. Voy. *Challenger*, Zool., Vol. 9, p. 729, Pl. 109, figs. 12, 13.

The interpretation of this species at the present day is such as to include forms showing considerable variation. The specimens from the Aragon are about as depressed as those figured by Brady; they have a less angled border than d'Orbigny's figured specimen and one side is more close-coiled than the other, as in Reuss' figured specimens from the Pliocene of Antwerp.

Family HANTKENINIDAE

HANTKENINA LONGISPINA Cushman

Hantkenina longispina Cushman, *1924*, Proc. U. S. Nat. Mus., Vol. 66, Art. 30, p. 2, Pl. 2, fig. 4; *1926*, Bull. Am. Assn. Petrol. Geol., Vol. 10, p. 299, Pl. 7, fig. 3; *1927*, Jour. Pal., Vol. 1, p. 160, Pl. 26, fig. 2; Cole, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 24, Pl. 4, fig. 7.

This name is best retained only for the very long-spined variety, forms grading into *H. mexicana* also being found.

HANTKENINA MEXICANA Cushman

Plate 23, figures 13, 17

Hantkenina mexicana Cushman, *1924*, Proc. U. S. Nat. Mus., Vol. 66, Art. 30, p. 3, Pl. 2, fig. 2; *1927*, Jour. Pal., Vol. 1, p. 160, Pl. 25, fig. 18.

This species was originally described from the Guayabal formation of Zardo Creek exposures, where it is associated with *Cristellaria mexicana* Cushman, *Nodosaria mexicana* Cushman, *Anomalina umbonata* Cushman, *Eponides guayabalensis* Cole and *Discocyclina cushmani* Vaughan. Cole[14] considered *H. mexicana* to be characteristic of the Aragon (unnamed formation in his table), while the form typical of this formation is the variety described below. *H. mexicana* occurs both in the Guayabal and Aragon.

HANTKENINA MEXICANA var. ARAGONENSIS Nuttall, n. var.

Plate 24, figures 1-3

This variety differs from the type in generally having larger more inflated chambers, which always taper more gradually into the terminal

[14]W. S. Cole, Bull. Am. Pal., Vol. 14 (1927), No. 51, p. 9.

spines. The latter are not infrequently broken as in figure 3. This form is a valuable and fairly common guide species for the Aragon.

FAMILY BULIMINIDAE

BULIMINA PUPOIDES D'ORBIGNY

Bulimina pupoides D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 185, Pl. 11, figs. 11-12; BRADY, *1884*, Rep. Voy. *Challenger*, Zool., Vol. 9, p. 400, Pl. 50, fig. 15.

This species has been observed in the Alazan, Guayabal and Aragon.

BULIMINA ELEGANS D'ORBIGNY

Plate 23, figure 12

Bulimina elegans D'ORBIGNY, *1826*, Ann. Sci. Nat., Vol. 7, p. 270, No. 10; BRADY, *1884*, Rep. Voy. *Challenger*, Zool., Vol. 9, p. 398, Pl. 50, figs. 1-4; CHAPMAN, *1892*, Quart. Jour. Geol. Soc., Vol. 48, p. 514, Pl. 15, fig. 9.

There appears to be no certain method of distinguishing this form as found in the Aragon from the living species, which in Europe has been recorded ranging back through the Tertiary into the Upper Cretaceous. This species is particularly abundant in the Chicontepec and uncommon in the Aragon, while very closely related forms range up sparingly into the Alazan.

BULIMINA SEMICOSTATA NUTTALL, N. SP.

Plate 23, figures 15, 16

Test cylindrical, elongate, tapering to a blunt point at the initial end, rounded at the apertural end. The last three or four chambers are smooth, sutures depressed, narrow, distinct. Earlier chambers indistinct, covered with fine, irregular, only slightly elevated longitudinal costae. Aperture short, straight. Average length 0.5 mm.

This species resembles *B. semistriata* d'Orbigny[15] from which it may be distinguished by its coarser striations and more elongate shape. It is frequent in the Chapapote, rare in the Guayabal and fairly common in the Aragon.

LOXOSTOMUM APPLINAE (PLUMMER)

Plate 24, figures 4, 5

Bolivina applini PLUMMER, *1926*, Univ. Texas Bull. 2644, p. 69, Pl. 4, fig. 1.

Test attenuate, subcylindrical, somewhat compressed. Biserial portion occupies generally somewhat over half the length of the test, gradually tapering to the initial end which is pointed. The biserial part

[15]Figured by Fornasini, Bull. Soc. Geol. Ital., Vol. 20 (1901), p. 200, fig. 5.

of the test is compressed, with sutures visible externally and surface covered with fine longitudinal striae. Uniserial part smooth, punctate, usually with four or five chambers of the same width throughout, sutures distinct with crenulate indentations. Aperture terminal, small, rounded, usually central, with a low poorly defined lip. Average length 1.1 mm.

The Mexican forms differ from the type in having the uniserial portion well developed, specimens such as that figured by Mrs. Plummer from the Midway of Texas being also found. This species has been observed in the Aragon and Chicontepec.

Family ELLIPSOIDINIDAE

PLEUROSTOMELLA ALTERNANS Schwager

Pleurostomella alternans Schwager, *1866*, Novara-Exped. Geol., Ser. 3, p. 238, Pl. 6. figs. 79, 80; Plummer, *1926*, Univ. Texas Bull. 2644, p. 69, Pl. 4, fig. 2.

This species, which has been observed in the Alazan and Chapapote is also present in the Aragon and Chicontepec.

PLEUROSTOMELLA aff. ALAZANENSIS Cushman

Pleurostomella alazanensis Cushman, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 5, Pl. 1, fig. 2.

Forms closely related to this species are found in the Aragon. They vary in the degree of inflation of the test; some specimens are well tapered and pointed, while others are blunt and rounded at the initial end.

Explanation of Plate 24

Figs. 1-3.—*Hantkenina mexicana* var. *aragonensis* Nuttall, n. var. × 40. Fig. 1. Arroyo Puentitla, 2600 m. N. 73° E. of El Tule. Figs. 2, 3. 1200 m. N. 48° W. of La Antigua.

4, 5.—*Loxostomum applinae* (Plummer). × 40. 2400 m. N. 32° E. of Camaitlan.

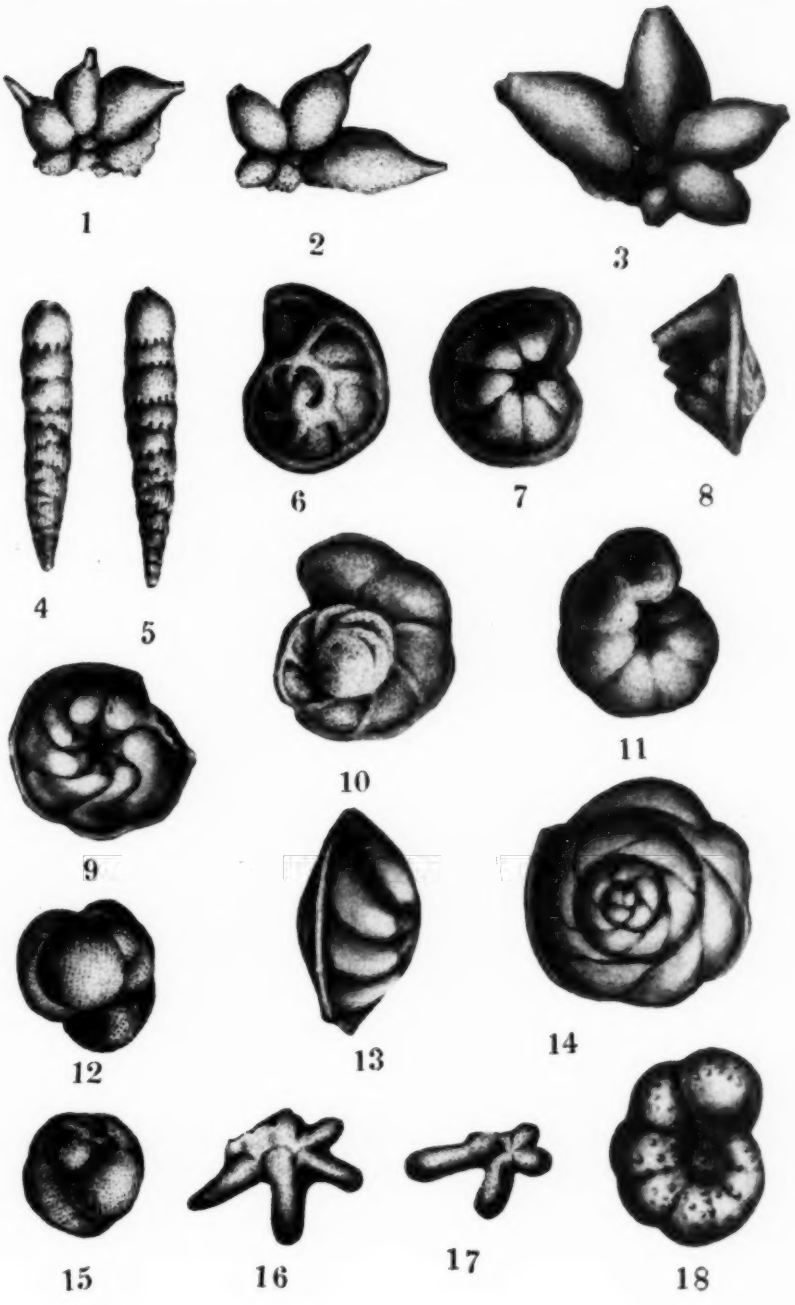
6-8, 10, 11.—*Globorotalia aragonensis* Nuttall, n. sp. × 40. La Antigua Rio La Puerta. Figs. 6, 10, dorsal view. Figs. 7, 11, ventral view. Fig. 8, side view.

9, 13, 14.—*Eponides trümpyi* Nuttall, n. sp. × 40. Fig. 9, ventral view; Rio La Puerta, 200 m. upstream from La Antigua crossing. Fig. 13, side view; 1850 m. N. 85° W. of El Tule. Fig. 14, dorsal view; Alazan well 33 from 2080 feet.

12, 15.—*Globigerina* sp. × 40. La Antigua, Rio La Puerta.

16, 17.—*Hasterigerinella eocanica* var. *aragonensis* Nuttall, n. var. × 20. Arroyo La Laja, 720 m. S. 70° W. of La Antigua crossing.

18.—*Anomalina dorri* var. *aragonensis* Nuttall, n. var. × 40. Ventral view, Rio La Puerta, 200 m. upstream from La Antigua crossing.



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ELLIPSONODOSARIA SUBNODOSA (GUPPY)

Ellipsoidina subnodosa GUPPY, *1894*, Proc. Zool. Soc. London, p. 650, Pl. 41, fig. 12.
Ellipsonodosaria subnodosa CUSHMAN, *1928*, Contr. Cushman Lab. Foram. Research, Vol. 4, p. 102, Pl. 14, figs. 15, 16.

This species is readily distinguished by its nodosarian test and lipped aperture. It has been observed in the basal Alazan, Chapapote, Guayabal and Aragon.

FAMILY ROTALIIDAE

GYROIDINA GIRARDANA (REUSS)

Rotalina girardana REUSS, *1851*, Zeitschr. Deutsch. Geol. Ges., Vol. 3, p. 73, Pl. 5, fig. 34.
Gyroidina girardana CUSHMAN, *1927*, Jour. Pal., Vol. 1, p. 164, Pl. 25, figs. 7-9; COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 15.

This species, which is present in the Aragon, ranges up into the lower part of the Alazan.

EPONIDES UMBONATA (REUSS)

Pulvinulina umbonata REUSS, *1851*, Zeitschr. Deutsch. Geol. Ges., Vol. 3, p. 75, Pl. 5, fig. 35.
Eponides umbonata COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 15; CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Research, Vol. 5, pt. 4, p. 98, Pl. 14, figs 8a-c.
Rotalia umbonata GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., Vol. 15, No. 55, p. 26, Pl. 5, fig. 1.

This species is found in the lower part of the Alazan, has been recorded by Cole from the Chapapote and is present in the Aragon.

EPONIDES TRÜMPYI NUTTALL, N. SP
Plate 24, figures 9, 13, 14

Test rotaliform, biconvex, dorsally slightly and ventrally strongly elevated. Border with a rounded peripheral flange. Dorsally smooth, with four or five visible whorls, slowly increasing in width. Sutures not elevated, thin, set at an acute angle to the outer chamber wall. In the earlier whorls only, the sutures do not always quite reach the inner chamber wall; in the later whorls they extend the whole distance across the chambers. Ventrally with a rounded central boss of clear shell substance, with about seven narrow radial sutures, which are slightly depressed toward the margin. At one-third of the distance from the center of the test to the border the sutures present a marked sub-angular sinuosity, extending forward in the direction of coiling. Aperture an elongate slit at the base of the last chamber, extending from the periphery the whole distance to the ventral boss. Average diameter 0.7 mm.

This very characteristic species resembles *P. promineus* Reuss[16], which, however, has different sutural features. It is of fairly frequent occurrence in the Chapapote, Guayabal and Aragon, while a small variety occurs in the Chicontepec. It is named for Dr. D. Trümpy, chief geologist of the Aguila Company.

Family GLOBOROTALIIDAE

GLOBOROTALIA CRASSATA (Cushman)

Pulvinulina crassata Cushman, *1925*, Bull. Am. Assn. Petrol. Geol., Vol. 9, p. 300, Pl. 7, fig. 4.
Globorotalia crassata Cole, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 34, Pl. 1, figs. 7, 8.

Typical specimens of this species are found in the Aragon, this form being however more common in the Guayabal.

GLOBOROTALIA SPINULOSA Cushman

Globorotalia spinulosa Cushman, *1927*, Contr. Cushman Lab. Foram. Research, Vol. 3, p. 114, Pl. 23, fig. 4; Cole, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 34, Pl. 1, fig. 9.

It is sometimes somewhat difficult to distinguish this species from *P. crassata*, which presents a rougher surface and more rounded border. It occurs in the Guayabal and Aragon.

GLOBOROTALIA ARAGONENSIS Nuttall, n. sp.

Plate 24, figures 6-8, 10, 11

Test plano-convex, dorsally slightly elevated, rotaliform. Dorsally with two visible whorls, the first being small and much obscured by supplementary shell growth. The last whorl has about seven chambers, separated by limbate sutures, which have a roughened surface and are for the most part raised, but not always clearly demarcated from the finely perforate chamber surface. Border subacute, sometimes slightly lobulate, with a narrow peripheral beading. Ventral surface elevated with generally six chambers, which have a roughened surface and are separated by narrow, deeply depressed sutures. At the center is a narrow deep umbilicus, sometimes partly filled with secondary growth, which may hide part of the aperture, which is an elongate slit extending from the umbilicus to near the periphery and situated at the base of the last chamber. Average diameter 0.6 mm.

This species is common in the Aragon and very rare in the Chicontepec. It is likely to be confused with *G. velascoensis* of the Velasco

[16]Sitz. K. Ak. Wiss. Wien., Vol. 59, pt. 1, p. 463, pl. 3, fig. 2.

shale,[17] but differs from typical specimens of the latter in having a smaller umbilicus, a smaller number of chambers in the last whorl and a more elevated dorsal surface.

FAMILY CHILOSTOMELLIDAE

CHILOSTOMELLOIDES OVIFORMIS (SHERBORN AND CHAPMAN)

Lagena (Obliquina) oviformis SHERBORN AND CHAPMAN, *1886*, Jour. Roy. Micro. Soc., p. 745, Pl. 14, fig. 19.
Chilostomelloides oviformis CUSHMAN, *1927*, Jour. Pal., Vol. 1, p. 168, Pl. 26, fig. 10; COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 16.

This species ranges from Alazan to Chicontepec.

PULLENIA SPHAEROIDES (D'ORBIGNY)

Nonionina sphaeroides D'ORBIGNY, *1826*, Ann. Sci. Nat., Vol. 7, No. 1, p. 293.
Pullenia sphaeroides BRADY, *1884*, Rept. Voy. *Challenger*, Zool., Vol. 9, p. 615, Pl. 84, figs. 12, 13.

This species occurs sparingly throughout the Tertiary of the Tampico embayment.

PULLENIA QUINQUELOBA REUSS

Nonionina quinqueloba REUSS, *1851*, Zeitschr. Deutsch. Geol. Ges., Vol. 3, p. 71, Pl. 5, fig. 31.
Pullenia quinqueloba BRADY, *1884*, Rept. Voy. *Challenger*, Zool., Vol. 9, p. 617, Pl. 84, figs. 14, 15.

This species is present in the Alazan, Chapapote and Aragon.

FAMILY GLOBIGERINIDAE

GLOBIGERINA TOPILENSIS CUSHMAN

Globigerina topilensis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, Vol. 1, p. 7, Pl. 1, fig. 9; COLE, *1927*, Bull. Am. Pal., Vol. 14, No. 51, p. 33.

This species is found in the Guayabal and Aragon.

GLOBIGERINA CRETACEA D'ORBIGNY

Globigerina cretacea D'ORBIGNY, *1840*, Mém. Soc. Géol. France, (1), Vol. 4, p. 34, Pl. 3, figs. 12, 13.

This species has been observed in the Aragon, Chicontepec and Velasco.[18]

[17] Jour. Pal., Vol. 2 (1928), No. 4, p. 281.

[18] For the latter see Jour. Pal., Vol. 2 (1928), p. 133, Pl. 8, Fig. 9.

GLOBIGERINA PSEUDOBULLOIDES PLUMMER

Globigerina pseudobulloides, PLUMMER, *1926*, Univ. Texas Bull. 2644, p. 133, Pl. 8, fig. 9.

This species is typical and fairly common in the Aragon, appearing to be identical with that described from the Midway of Texas.

GLOBIGERINA SP.

Plate 24, figures 12, 15

This species resembles *G. orbiformis* Cole, but the figure and description of this species are poor, rendering specific determination uncertain.

HASTIGERINELLA EOCANICA VAR. ARAGONENSIS NUTTALL, N. SP.

Plate 24, figures 16, 17

Hastigerinella eocanica NUTTALL, var., *1928*, Jour. Pal., Vol. 2, No. 4, p. 376, Pl. 50, figs. 9-11.

This species differs from the form described from the Isthmus of Tehuantepec in having more elongate chambers. These are, however, not as attenuate as those of *H. jarvisi* Cushman.[19] The terminations are also smooth and rounded and never spinose as in the latter species. This variety has so far only been found in the Aragon of the Tampico region.

[19]Contr. Cushman Lab. Foram. Research, Vol. 6, 1930, pt. 1, p. 15.

EXPLANATION OF PLATE 25

FIGS. 1.—*Anomalina dorri* var. *aragonensis* Nuttall, n. var. × 40. Dorsal view. Rio La Puerta, 200 m. upstream from La Antigua crossing.

2, 4.—*Cibicides tuxpamensis* Cole. × 20. Fig. 2, dorsal view. Fig. 4, ventral view. La Antigua, Rio La Puerta.

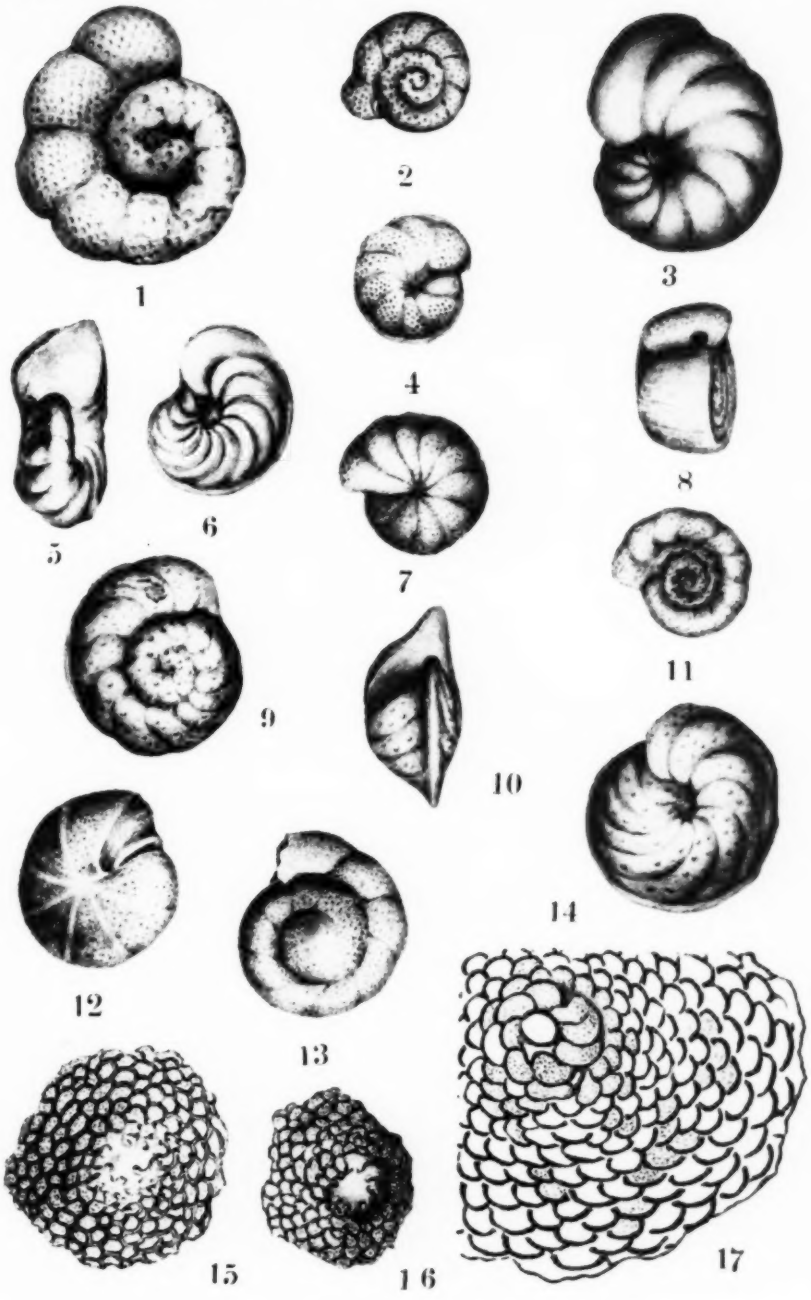
3, 5, 6.—*Cibicides cushmani* Nuttall, n. sp. × 40. Fig. 3, dorsal view. Fig. 5, side view. Fig. 6, ventral view. La Antigua, Rio La Puerta.

7, 8, 11.—*Cibicides grmisdalei* Nuttall, n. sp. × 40. Fig. 7, ventral view. Fig. 11, dorsal view. Rio La Puerta, 200 m. upstream from La Antigua crossing. Fig. 8, side view, 1670 m. N. 70° W. of La Antigua crossing.

9, 10, 14.—*Cibicides subspirata* Nuttall, n. sp. × 40. La Antigua, Rio La Puerta.

12, 13.—*Cibicides pygmaea* (Hantken) × 40. La Antigua Rio La Puerta.

15-17.—*Planorbulina* (*Planorbulinella*) *guayabalensis* Nuttall, n. sp. Macatepec well 5, core at 4590 feet. Figs. 15, 16, × 20. Fig. 17, equatorial section, × 40.



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FAMILY ANOMALINIDAE

ANOMALINA DORRI VAR. ARAGONENSIS NUTTALL, N. VAR.

Plate 24, figure 18; Plate 25, figure 1

Anomalina dorri COLE, var., *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 18, Pl. 3, figs. 1, 2.

In both the type of the species from the Chapapote and the varietal form from the Aragon the dorsal surface shows generally two whorls and is only slightly umbilicate. On the ventral surface only the last coil is visible and a deep umbilicus is present. The amount of beading on the sutures is variable and the test is coarsely punctate.

The variety differs from the type in certain minor but constant details. The test is smaller and the sutures in the ultimate half of the last whorl are more sharply defined, also more depressed. Average diameter 0.6 mm.

A. dorri is common in the Chapapote and rare in the Guayabal, while this variety is present in the Aragon and Chicontepec.

CIBICIDES CUSHMANI NUTTALL, N. SP.

Plate 25, figures 3, 5, 6

Test plano-convex, the dorsal side flattened or even slightly concave, the ventral side rounded except in the umbilical region which is somewhat depressed; periphery subacute, about ten chambers in the last formed coil; sutures distinct, on the dorsal side limbate, of clear shell material, somewhat broader toward the inner chamber margin, ventrally somewhat depressed or else limbate; wall between the sutures finely punctate; aperture peripheral at the base of the last-formed chamber, elongate, arched, with a slight trace of overhanging lip. Diameter up to 0.5 mm.

This species has been observed to range from the Lower Alazan to Aragon. It is named in honor of Dr. J. A. Cushman.

CIBICIDES TUXPAMENSIS COLE

Plate 25, figures 2, 4

Cibicides tuxpamensis COLE, *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 19, Pl. 1, figs. 2, 3; Pl. 3, figs. 5, 6.

The range of this species is from Lower Alazan to Aragon.

CIBICIDES GRIMSDALEI NUTTALL, N. SP.

Plate 25, figures 7, 8, 11

Test small, plano-convex, dorsally practically flat, ventrally much elevated. Border sharp, no umbilicus on either surface, finely perforate.

Dorsally with about two visible whorls with short, gently curved, limbate sutures. Ventrally with fairly thick limbate sutures, which are not depressed, the last whorl only being visible with about ten chambers. Aperture small, arched, near the dorsal peripheral margin. Average diameter 0.4 to 0.5 mm.

The above species is, as far as is at present known, restricted to the Aragon. It is named for T. Grimsdale, who collected most of the material described.

CIBICIDES SUBSPIRATA NUTTALL, N. SP.

Plate 25, figures 9, 10, 14

Test biconvex, rotaliform, dorsally slightly elevated, ventrally more convex; border acute with a narrow flanged keel. Dorsally with two visible whorls, chambers finely perforate, about ten in the last whorl; sutures narrow, not very distinct, gently curved. Ventrally with a central boss of clear shell substance, generally of small size; sutures distinct, depressed, strongly curved. Aperture a short arched slit, extending over the peripheral margin to the base of the last chamber. Average diameter 0.6 mm.

This species resembles *Truncatulina ungeriana* var. *radiata* Toula[20] from which it is distinguished by the externally visible earlier chambers on the dorsal surface and the more strongly curved sutures on the ventral surface. *Cibicides mckannai* Galloway and Wissler[21] appears to be synonymous with this last variety. *Truncatulina spirata* Seguenza[22] has a different aperture and more whorls on the dorsal surface. This species has been observed in the Aragon and Chicontepec.

CIBICIDES AFF. ALLENI (PLUMMER)

Truncatulina alleni PLUMMER, *1926*, Univ. Texas Bull. 2644, p. 144, Pl. 10, figs. 4 a-c.

Forms closely related to this species occur, which show variation in the convexity of the dorsal surface and the amount of secondary shell development on the same surface.

[20]Jahrb. K. K. Geol. Reichanst., Vol. 64 (1915), p. 657, Pl. 39, fig. 16.

[21]Jour. Pal., Vol. 1 (1927), p. 65.

[22]Atti. R. Acc. Lincei, Ser. 3, Vol. 6 (1880), pp. 91, 149, Pl. 14, fig. 4.

CIBICIDES PYGMAEA (HANTKEN)

Plate 25, figures 12, 13

Truncatulina pygmaea HANKTEN, *1875*, Mitth. Jahrb. Ungar. Geol. Anst., Vol. 4, Pl. 10, fig. 8.
Cibicides pygmaea CUSHMAN AND APPLIN, *1926*, Bull. Am. Assn. Petrol. Geol., Vol. 10, p. 179, Pl. 3, fig. 14.

The specimens referred to this species from the Aragon are very smooth and finely perforate, with the sutures on both surfaces not clearly visible. The border is subacute and the ventral umbilical area filled with shell substance, as in specimens figured by Brady.[23]

PULVINULINELLA (?) CULTER VAR. MEXICANA COLE

Pulvinulinella culter CUSHMAN, *1927*, Jour. Pal., Vol. 1, p. 167, Pl. 26, figs. 8, 9.
Pulvinulinella culter var. *mexicana* COLE, *1927*, Bull. Am. Pal., Vol. 19, No. 51, p. 31, Pl. 1, figs. 15, 16; *1928*, Bull. Am. Pal., Vol. 14, No. 53, p. 15.

This species ranges from the lower part of the Alazan to the Aragon. It appears doubtful if *Planorbulina culter* Parker & Jones should be referred to *Pulvinulinella*, the aperture in the genotype of the latter being very different from that of the former species.

[23]Rept. Voy. *Challenger*, Zool., Vol. 9 (1884), Pl. 105, figs. 9, 10.

PALEONTOLOGICAL NOTES

JONESITES, A NEW NAME FOR THE OSTRACODE GENUS *PLACENTULA*

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In 1822 Lamarck[1] described a new genus of Foraminifera under the name of *Placentula* as follows:

> Coquille orbiculaire, convexe en dessus et en dessous, multiloculaire. Ouverture oblongue, étroite, disposée comme un rayon dans le disque inferior ou sur les deux disques.

This genus was erected to include two species, *Nautilus repandus* and *N. asterizans* (Figs. 1a, b), described and beautifully figured by Fichtel and Moll.[2] A further study of the validity of the name *Placentula* and the proper distribution of the species grouped here by Lamarck becomes a foraminiferal problem and quite outside the scope of this paper.

In 1886 Jones and Holl[3] described a new genus of Ostracoda using the same name that Lamarck had erected in 1822. They described the genus as follows:

> Valves suborbicular, nearly semicircular on the ventral border, straight on the dorsal margin inside, but projecting with unequal and variable angles at the outer dorsal region. Surface flat or slightly convex, surrounded by a raised rim, which slopes down suddenly outside to the edge of the valve. This rim encloses a depressed and reticulated area and in or near the antero-dorsal region there is a small depression defined by a raised loop-like border.

Placentula Jones and Holl is monotypical, with *Primitia excavata* J. & H.[3,4] as the genotype. The figure of the type specimen of the species (Fig. 1c) was not reproduced to illustrate the genus, but instead Jones and Holl selected and figured three autotypes from the material collected

[1] J. B. Lamarck, Hist. Nat. *Animaux sans Vert.* (1822), tome 7, p. 620.

[2] Leopold Fichtel and J. P. C. Moll, *Test. Micro* (1798), Pl. 3, figs. a and d.

[3] T. R. Jones and H. B. Holl, *Ann. & Mag. Nat. Hist.* (1886) (5), Vol. 17, p. 407.

[4] T. R. Jones and H. B. Holl, *Ann. & Mag. Nat. Hist.* (1869), (4) Vol. 3, p. 222, Pl. 15, figs. 10 a, b, c.

by Vine. When Ulrich and Bassler[1] redescribed *Placentula* they selected one of the figures of the autotypes (Fig. 1d).

According to article 34 of the International Rules of Zoological Nomenclature the ostracode genus *Placentula*, preoccupied by Lamarck since 1822, must be rejected as a homonym. It is then in order to propose a new name for the ostracodes as described and figured by Jones and Holl. In honor of the senior author of the fossil Ostracoda the name *Jonesites* is here proposed to replace *Placentula*, with *Primitia excavata* J. & H. as the genotype.

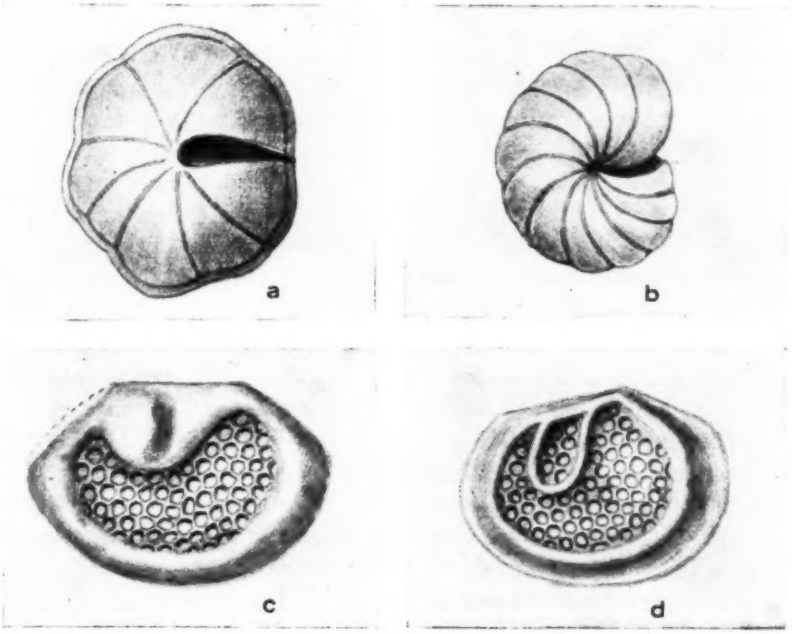

FIG. 1. (a) *Nautilus repandus* Fichtel and Moll, diam. ½ line (× 40). Mediterranean, Recent. (b) *Nautilus asterizans* Fichtel and Moll, diam. 1-3 line (× 40). Mediterranean. Recent. (c) *Primitia excavata* Jones and Holl, left valve (× 60). England, near Malvern, Woolhope limestone, Silurian. (d) *Placentula excavata* Jones and Holl, left valve (× 45). Length 11 mm., height 7 mm., thickness 5 mm. Vine collection. Upper Wenlock shale, Silurian.

[1]E. O. Ulrich and R. S. Bassler, *Maryland Geol. Survey*, Silurian (1923), p. 301.

THE DATES OF PUBLICATION OF TEMPÈRE AND PERAGALLO'S *DIATOMÉES DU MONDE ENTIER*, EDITION 2

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Under the title given, Tempère and Peragallo published one of the most valuable books on diatoms that has appeared. It is particularly useful to students of American micropaleontology, although, as the title implies, the material upon which the work is based came from many parts of the world and includes both recent and fossil species, freshwater and marine. The main part of the text (480 pages) contains lists of species found in 995 separate collections, comprising about 900 localities. The United States is represented by 118 localities, 34 being from the far west. Most of the famous localities of diatom literature are represented by fairly complete and accurate lists of species. This portion of the work is followed by 68 pages (separately paged) containing a classified list of localities and an index.

Unfortunately many of the localities from which fossils were listed are not very definite and some are actually erroneous. However, the authors are hardly to be blamed for this because the material from the United States at least, was received from correspondents. A considerable number of new species and several new genera are described but are not accompanied by figures.

Publication of the work began in 1907 and was completed in 1925, the various parts being issued as fascicules of varying sizes and without dates. On account of the new names appearing in the book it is desirable to have definite date records of the several fascicules. Accordingly I made a request for the information from M. L. J. Laporte, successor in Paris to the late M. J. Tempère. In a letter dated May 23, 1928 (now on file at the California Academy of Sciences) he very kindly furnished the dates incorporated in the following table:

Fascicule number	*Pages*	*Date*
1	1–16	1907
2–7	17–112	1908
8–12[a]	113–208	1909
13–16	209–256	1910
17–19	257–304	1911
20–23	305–352	1912
24–28	353–448	1913
29–30	449–480	1914
Tables and index	1–68	1915

[a]Fascicule 10 is duplicated.

In so far as the publication had preceded 1910 the dates given by M. Laporte agree with those published by Azpeitia in 1911.[1]

Edition 1 of this work is entitled "*Diatomées Collection J. Tèmpere & H. Peragallo.*" It was published in Paris but contains no date. The Catalog of the Library of the British Museum gives the dates "1889-1895" but at the present time I have no means of knowing the exact date of publication of the several parts. This first edition contains lists of species from 625 separate collections, 29 of which are from western North America. This portion of the work contains 304 pages; in addition there is an index of localities and an alphabetical index of genera and species covering 62 pages (separately paged.) On comparing the two "editions" they are found to have almost nothing in common; they are apparently catalogs of entirely different collections of diatoms and and, although the same localities may appear in both the lists of species show that different material has been studied in the two cases.

THE OSTRACODE GENUS *HOLLINELLA*

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In a recent article by Kellett on the ostracode genus *Hollinella*[2] some statements appear which should not pass without comment. Attempting to explain the occurrence in different horizons of parallel forms classed as *Hollinella*, this writer refers three forms in each horizon to the same species, on the assumption that they represent male, breeding female, and nonbreeding female. Such an assumption, while perhaps not entirely absurd, is so highly improbable as to be, at present, quite unacceptable.

In addition, reference is made to "numerous moults." So far as I can find, recent ostracodes are not known to have more than nine stadia (eight moults) and G. W. Müller[3] definitely denies any moults following maturity. He says of the Cytheridae (p. 422): "Mit der 8. Häutung wird das Tier geschlechtsreif, weitere Häutungen folgen nicht. (Bei

[1] *Assos. Esp. Prog. Cien. Cong. Zargoza* (1911), Vol. 4, Sec. 3, Cien. Nat. Pt. 2, p. 61.

[2] Betty Kellett (1929). The ostracode genus *Hollinella*, expansion of the genus and description of some Carboniferous species. *Jour. Pal.*, Vol. 3, pp. 196-217, 2 pl.

[3] G. W. Müller, Ostracoda = Muschelkrebse. Kükenthal and Krumbach, *Handb. Zool.* (1927), Vol. 3, pp. 399-434, 37 figs.

keinem Ostracoden nach erlangter Geschlechtsreife.") The italics are Müller's. It is certainly unreasonable to suppose that the Beyrichiidae differ essentially in this respect from recent Podocopa.

Aside from the question of the number of moults, it is extremely improbable that any female ostracode undergoes marked change of form in fluctuating between breeding and non-breeding states. The phenomenon of periodomorphosis is, to be sure, well known among arthropods but appears to be confined to males and is not known in any of the Entomostraca.

From my own studies of recent Ostracoda I can put forward two suggestions as to the use of those perplexing frills. First, they may have served to protect the appendages when projected from the valves. Second, and more likely, they may have served as outriggers to prevent the animal from sinking too deeply into the soft mud, on the surface of which many forms live. It is, of course, possible that the frill subserved no function whatever. A study of transverse sections might help decide this point. In any case the frills can scarcely form an incubatory chamber, since in all the recent types possessing such a chamber it is posterodorsal in position. *Xestoleberis aurantia* is a good example. I cannot agree with the explanation quoted from Ulrich and Bassler that the space is "for the temporary lodgment and protection of broods of young." I know of no crustacean that takes the slightest interest in its young after they once leave the mother. If any sexual dimorphism is to be found it will be in the posterodorsal region primarily. Further, it is by no means clear that the distal margins of the frills are sufficiently approximated ventrally to form a chamber of any sort. If the frills did form a brood-chamber, it is obvious that this would effectively inhibit both feeding and locomotion, a fatal objection.

On the basis of the foregoing remarks, I hold that each of the three forms in each horizon at present grouped together is a distinct species representing one of three parallel lines of evolution and should be so named.

The distinction which is supposed to be established on pp. 199-200 between *Hollina* and *Hollinella* is so hazy that I cannot make any definite criticism nor, indeed, distinguish the genera. However, I feel that, in the absence of other characters, the presence or absence of the frill is not of generic rank.

Miss Kellett may be commended highly for her valuable description of the hinge structure of these animals.

METHODS AND TECHNIQUE

THE PREPARATION OF PALEONTOLOGIC ILLUSTRATIONS

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ABSTRACT

The preparation of illustrations is a most important part of a paleontologic contribution but it is a subject on which little is written. This paper discusses briefly matters in this field, with special reference to the *Journal of Paleontology*.

INTRODUCTION

It is perhaps a mere platitude to say that paleontologic illustrations are intended to supplement, even in considerable part to replace, verbal descriptions, and that only when they actually show the features of the specimens represented are they worth the time, the effort, and the expense necessary to produce them. In spite of these seemingly obvious facts, however, one may find in current literature many illustrations of inferior quality, some so far below the ideal that one wonders just what the authors could have expected to accomplish by publishing them. In some cases the faults are due to carelessness in preparation, in others perhaps to inexperience or lack of acquaintance with a few elemental principles. It is true, to be sure, that the engraver may make a poor cut from a good original illustration or the printer may make a poor job of the printing from an excellent cut, but by far the greater part of the defects of poor illustrations are in the originals and are chargeable to the author. Even though many of us lack the particular facilities and abilities necessary for the highest grade of paleontologic illustration, it is possible through attention to details, a reasonable amount of care, and forethought, for any of us to turn out original illustrations which the engraver and the printer will convert into very useful and entirely acceptable final illustrations.

GENERAL MATTERS

Limitations imposed by methods of engraving. The *Journal of Paleontology* uses photo-engraving for all illustrations and particularly half-tone engraving and zinc etching.[1] In these a printing surface is produced in relief on a metal plate and the printing done on an ordinary printing press.

In engraving by the half-tone process originals with tones intermediate between black and white—photographs, brush-drawings in lampblack or india

[1]Some of the plates in the *Journal* are now reproduced by a photo-gelatin process. the technique of which differs from half-tone engraving, but requirements of good "copy" are the same.—Editor.

ink, or shaded pencil-drawings—may be reproduced, for the engraver imitates the intermediate tones by producing a pattern of small dots, larger and closely set for dark tones, smaller and more widely spaced for lighter tones.[1] In comparison with the original there is always some loss of contrast and of fine detail in a half-tone engraving, for there are no pure white high-lights and the small dots do not reproduce fine lines smoothly and sharply. In addition, the half-tone engraving reproduces the entire original, background and all, and extra cost in incurred in removing the background when it is not desired.

In zinc etching, also called line engraving, only black and white may be shown by the originals and any simulation of intermediate tones must be produced in the originals by some pattern of black dots, lines, or masses of proper size and spacing—as in pen-drawings, stipple-drawings, etc. For best results it is important that the originals show sharply defined black elements on a clear white background, though, unlike half-tone engraving, nothing in the background is reproduced and only the black design shows in the finished cut.

It is possible to make a combination engraving, containing both half-tone and line work—for example, half-tone pictures of specimens and line engraving of the figure numbers, outline cross-sections, etc.—but the cost is considerably more than that of a plain half-tone, which in turn is considerably more than that of a zinc etching.

Lighting. It is the most widely accepted convention to show individual figures with the light coming from the upper left corner. This convention has not been uniformly followed in the past and is sometimes disregarded to-day, but seems for the sake of uniformity to be the most desirable. It is particularly undesirable to mount the individual figures composing a plate in such manner as to show differing directions of lighting.

Size. Original illustrations may be made publication size, but owing to the unavoidable loss in engraving, results will be better if the originals are made somewhat larger than publication size, say one and one-half times. The intent of the author as to size must be made clear, however, especially where publication size is greater or less than natural size, in order that the enlargement or reduction marked on the figure or stated in the description be true for the figure as printed.

It is desirable, wherever it is possible to do so, to use the same magnification for all figures in a plate, as this facilitates comparisons.

The publication size of plates in the *Journal of Paleontology* is 4 1-6 by 6¾ inches.

Number of illustrations. No rule can be laid down as to what constitutes adequate illustration. In general any reasonable number of views to show different aspects of a specimen, or particular variants of a species, etc., is acceptable. Some fossils are adequately shown by one view; others require four or five. The number of plates is, of course, dependent on the number of individual figures. Common sense must be the guide as to what is desirable in a particular case and as to the wisest use of the available space.

[1]See John L. Ridgway, The preparation of illustrations for reports of the U. S. Geological Survey (1920), p. 72, (Superintendent of Documents, Government Printing Office, Washington, D. C., 15 cents), or some encyclopedia.

Materials. Illustrations may be photographic, brush-drawings, shaded pencil-drawings on smooth or stipple board, or line-drawings in black ink on bristol board or other good white background. Less desirable are line-drawings in pencil but they may be used.

Some paleontologists consider only unmodified photographs permissible in paleontologic illustration. Undoubtedly a perfect photograph, without retouching or other introduction of the subjective element and hence error, is the most desirable form of illustration. Such photographs are rare, however, because photography has strict limitations and fails to record much that the human eye can see. Between the imperfections of photography, which leaves out much that the eye can see, and the imperfections of the human hand, which presents in a drawing a somewhat inaccurate picture, there seems little to choose. It would seem the part of wisdom to try to secure the best of both methods of illustration, using either alone where adequate and combining them where it is useful to do so.

Though not strictly paleontologic illustrations, such matter as tables of distribution accompanying paleontologic papers may often be done in hand lettering or in clean black typewriting with black ink lines to form the boxes and reproduced as a zinc-etching at less cost than by setting up in type, and without the possibility of introducing typographical errors by the printer.

THE INDIVIDUAL FIGURE

Individual figures, in most instances to be later combined into plates, may be made by photography or by drawing, the method depending in part on the facilities available and in part on the features of the specimens. A combination of the two methods may be effected by retouching—strengthening or actually drawing in on a light print such features as need emphasis or as fail to appear with sufficient clearness in the photograph; or by using a photograph as a basis for a drawing.

Photography. Differences in equipment and in taste as to details of method limit suggestions about photographic figures of fossils to rather general remarks, most of which perhaps are already known to the reader.

Clean the specimen as thoroughly as possible. Fragments of matrix and adhering materials all show and detract much from the figure.

Many fossils afford very much better figures if white-coated by the well-known ammonium chloride process. This is particularly true of dark or varicolored specimens, but even light-colored specimens are improved. The coating of ammonium chloride is so fine in grain that, if applied lightly, considerable enlargement may be made without showing it (the process is being continually used at ×20). A little practice indicates the best density of coating, but it is always better to make it as thin as possible. Too heavy an application has led many to think the method of little value, as indeed it may be under such circumstances. Ammonium chloride appears somewhat bluish in color, particularly over dark surfaces, and photographs whiter than it appears to the eye—the photographic effect of a very tenuous film of it is surprising. Owing to the instability of the coating of ammonium chloride in warm, damp weather,

[1]See *Maryland Geol. Survey*, Silurian (1923), pp. 281-83.

it is of less service then than in dry, cool weather. In general it is best to have the specimen mounted, in focus, and ready for the exposure before applying the coating.

Natural light usually gives more satisfactory results than artificial light, especially for objects with high relief. Artificial light often gives harsh effects from too great contrast, and a somewhat unnatural appearance. It is, however, satisfactory for some things, particularly if the relief of the specimen is low or there is a color contrast—for example, dark imprints of fossil leaves on a fairly light background. For transparent sections the source of light is, of course, not of great importance.

To eliminate the background against which the photograph was made and thus cause the figure to stand out, the parts of the negative surrounding the image of the specimen may be "painted out," that, is, covered with red opaque or colored with a red dye, such as neococcin, so that they print white. Another scheme is to blacken the entire background on the finished print with lampblack, peach black, or Devoe show-card color. India ink may also be used but gives a glossier black.

Red opaque sometimes flakes off of a negative upon drying. This is due to insufficient washing of the negative or traces of grease from handling and may be prevented by a small amount of oxgall—as little as will be taken up by a moist brush is enough—mixed with the paint.

Red cellophane, the transparent material used for wrapping candy, etc., has been used for blocking out backgrounds. The cellophane is laid on the negative, the outline of the figure traced with ink and the part within the outline removed with small scissors, a sharp knife, or a fine needle. The cellophane sheet is then replaced and adjusted to fit exactly. A little adhesive at the corners will hold it in place. Prints now made from the negative will be white where the red cellophane filters the light.

A negative containing areas of very deep shadow which prints too black in comparison with the remainder of the picture may cause trouble. Some paleontologists are having success in improving such negatives by painting a faint tint of red or yellow dye over the shadow and thus slowing up its printing speed to a rate more in accord with the remainder of the negative. Experience must be the guide in using this method. The same result may, of course, be attained by the older method of part-time shading of the part of the negative which prints too dark.

Retouching. For extensive retouching, prints on dull-surfaced paper are needed and somewhat lighter in tone than would serve best for direct reproduction. The high lights are brought up by carefully scratching the surface of the paper or by touching up with a fine brush and chinese-white water color. The shadows and outlines are strengthened with a fine brush and lampblack or india ink, and some of the finer details with pencil, though a large amount of pencil is undesirable because the graphite gloss sometimes affects the reproduction seriously. Glossy prints may be retouched to a limited extent by slightly roughening the surface with pumice powder rubbed on with the finger at the point where the work is to be done. The powder must be brushed off completely before the retouching is done. Where the degree of contrast and the detail of

[1]See Albert Mann, *Science*, Oct. 25, 1929, p. 408.

the original photograph are satisfactory, it will often be adequate merely to outline the figure by a fine black line. Where no retouching is to be done, prints on glossy paper give better detail than dull-surfaced paper.

Drawings. The method to be used in the production of drawings of fossils is, like photography, so largely a matter of individual taste and skill that only generalities again may be offered.

Drawings may be made with brush and lampblack or india ink, or with pencil, or with pen and ink. Reynolds bristol board furnishes the best surface on which to draw fossils with pen, pencil, or brush, though other drawing board or paper with good surface can be used. Pencil or black crayon on Ross relief hand-stipple paper serves well for shaded drawings to be reproduced by zinc etching, though great care must be exercised in handling them to avoid smudging.

Mechanical aids help to get correct outline and proportions in drawing directly from the specimen. For larger specimens ordinary dividers or proportional dividers afford measurements which may be plotted as a basis for sketching. For very large specimens the pantograph can be adapted for good service in making a reduced outline, etc. For small specimens the camera lucida offers a convenient method. Some specimens may be sketched by placing them on a grilled background and drawing the outlines, etc., on the corresponding parts of a similar grill of the same or a different scale, perhaps a less satisfactory and less accurate method than the others.

Drawings may be made on a photographic base, this serving to give the outline and the position of the conspicuous features. One method is by tracing on a transparent sheet, then transferring the tracing by any of the ordinary draftsman's methods to white paper and adding there such details as may be desired. Another method is by drawing with waterproof ink directly on a blueprint, a bromide print, or an ordinary print and then bleaching out the photograph to leave the black lines on a white background. The bleaching solution for blueprints is potassium oxalate or bicarbonate of soda, and for bromide prints is potassium cyanide to which a little iodine has been added.[1] For ordinary developing paper a good bleaching solution is secured by mixing 7 cc. of a saturated solution of potassium permanganate and 7 cc. of concentrated hydrochloric acid in 8 ounces of water. The drawing must be of waterproof ink and thoroughly dry before bleaching to secure a clear figure, and should be in a finished state, as the paper is porous after bleaching and additional work on the subject is less sharp.

THE ASSEMBLED PLATE

Mounting board. The figures to compose a plate should be mounted on board rigid enough for much handling and with good enough surface to take ink well. Cut enough boards to serve the project in hand, all exactly the same size to facilitate handling and large enough to leave an inch or two-inch margin all around the plate. Measure on one the rectangle of the size chosen for the plate and draw the outline. The others may now be similarly marked by pricking through the corners of the first one and connecting the marks so made.

[1]See Ridgway, cited above, pp. 68-69.

A paper cover-sheet should be provided for each plate, long enough to cover the plate itself but leaving the lower border uncovered for editorial notations. The cover sheet should be fastened along the upper margin but need not be in place until the plate is completed, when its protection is needed to prevent rubbing the figures, etc.

EXPLANATION OF PLATE 26

Figures of a rather poor specimen of an ammonite to show the effects produced by various ways of handling the problem of its illustration. 1-8, half-tone, no routing; 9-11, 13, half-tone, interspaces routed; 12, half-tone, full routing; 14-16, zinc etching.

FIG. 1.—An untouched photographic print of medium tone showing the matrix of the specimen and part of the background against which the photograph was made. Number hand-lettered below center of figure.

2.—A similar print with the specimen outlined by a thin black line.

3.—A somewhat lighter print with the matrix and background blackened with india ink. White numbers on black ground glued on at bottom center of figure. No retouching.

4.—A somewhat darker print with matrix and background blackened with lampblack; figure lightly retouched. White number on black ground glued on at lower right corner.

5.—A print with the matrix and background retouched to an even gray tone and the specimen all practically drawn in on the photographic base—a maximum of retouching. Black printed number on a white ground glued on at bottom center of figure.

6.—The photographic figure, lightly retouched, closely trimmed out of the remainder of the photograph and mounted on white bristol board. Original print rather dark. Hand-lettered number at bottom center of figure.

7.—The photographic figure, lightly retouched, with the matrix and background removed by scraping the print until the white paper showed. It is nearly the same result as that obtained by "painting out" the negative before making the print. Black printed number on white ground glued on at bottom center of figure.

8.—A lightly retouched print with the matrix showing and the background blackened to complete the rectangle. Black printed number on white ground glued on at bottom center of figure.

9.—An over-dark print, the figure faintly outlined. Black printed number on white ground glued on at bottom center of figure.

10.—A print over-light in tone for engraving but not too light for extensive retouching. Figure faintly outlined. Hand-lettered number at bottom center.

11.—Pen and ink drawing over the photograph. The photograph may now be bleached out and the ink lines left on a white ground. Hand-lettered number at bottom center.

12.—The photographic figure, lightly retouched, with matrix and background routed from the engraving. Black printed number on white ground glued on under center of figure.

13.—A brush-drawing. Black printed number on white ground glued on below center of figure.

14.—Pen-drawing. Black printed number on white ground glued on below center of figure.

15.—Pencil-drawing on stipple paper. Black printed number on white ground glued on below center of figure.

16.—Samples of white numbers on black ground and black numbers on white ground.

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UNIV. OF MICH.

Arrangement of figures. Although the assembled plate, as stated in the beginning, is primarily intended for practical use and not for mere ornament, it is nevertheless very desirable, and indeed well worth while, to expend some thought and effort on effecting the most attractive arrangement possible with the material in hand. Some compromise often has to be made with the ideal and a more pleasing arrangement modified because of limitations of space, size and character of the figures, desire for a particular order, etc. Yet it is usually possible to take more or less into account such ordinary rules of artistic composition as that of placing larger and darker figures below, smaller and lighter ones above.

Square up the margins of the individual figures first, even when the background has been painted out, and study various arrangements before fastening any figures down. When a satisfactory order is secured, mark the place for each figure by pencil dots at the corners. Give each figure and its space a temporary number. The figures may then be removed and replaced at will without losing the selected order of arrangement.

A better effect is presented if the outer rows of figures all around the plate are aligned on the outer margins, i. e., if they just touch the outer margins.

The figures should look "straight," e. g., the axis of a gastropod should be vertical and parallel to others; and centered, each in its space. In trimming the figures, a pair of small celluloid triangles is a very handy aid. One triangle is placed on a directing line, such as an axis, and the margins perpendicular and parallel to it then drawn with the help of the other triangle. A clear square of glass, such as a lantern slide will also serve. In general, blocks or masses look better if they are accurately rectangular and the margins set parallel to those of the plate.

The plate is more convenient for the user if the several views of one specimen are mounted close together. Also if the order of the figure numbers is from upper left margin across to the right, then beginning again at the left, much as the lines of a printed page run, though it is sometimes better to number the related figures in a plate in sequence, regardless of where they fall in the plate.

Do not either waste space or crowd—a "wide-open" plate is wasteful of space that might well be put to better use and is not at all pleasing to the eye; an over-crowded plate is a poor economy and is very hard to use, and is besides equally displeasing to the eye. No rule other than common sense and good taste can be laid down to govern. It is better to make a plate smaller than the maximum permissible than to space it out with a few figures widely separated.

Mounting figures. Various mediums may be used for mounting the figures of a plate. However, as original figures are not infrequently used again in some other connection than that of the moment, it is unwise to mount them so securely that they cannot be removed without damage. At the same time it must be remembered that the original illustrations are to be handled by a number of people and that confusion may result if some one other than the author must replace several loosened numbers or figures. Furthermore, if the margins of the figures are loose, they may show too conspicuously in the engravings.

One of the best adhesives is the modern semi-liquid photo paste with a little glue added to give more "body," though a good glue alone is satisfactory if handled carefully. Its color causes it to show conspicuously in an engraving if an excessive amount is used and not removed from the finished plate with care.

Perhaps the simplest method of fastening the figures to the mounting board tightly enough for safe handling and yet not so tightly as to prevent removal is that of applying a small amount of the adhesive around the edges of the individual figures—not a great deal is needed, as may be found by trial, certainly not enough to spread and show beyond the edges of the figure. A small camels-hair brush is the best tool, not too much adhesive being taken up at a time. Pressure should be applied—by a screw press, such as the old fashioned office letter-press if one is at hand, or by any other means available—and the adhesive given a little time to set. It is well to use a sheet of white blotter over the face of the plate while in the press, as it will help to take up any excess adhesive that may have been used. It is best not to put more than a few figures on the mounting board at one time, slipping them under the press for a minute or two and then removing them to inspect for excess adhesive around the margins of the figures, etc. When well mounted in this fashion the figures will stick tightly enough for any ordinary use but may easily be stripped off with the aid of a knife.

Another very satisfactory mounting material that is extensively used by commercial artists is rubber cement or frisket cement which consists of pure rubber in a fluid solvent such as benzol. It may be purchased in can or tube and has the advantage that any excess beyond the edges of the mounted print may be removed completely simply by rubbing gently with the finger. The mounting is firm but the print can easily be removed if desired. This cement does not curl the paper.

Mount the whole plate before putting on the figure numbers.

Numbering figures. Figures may be numbered by drawing the numbers directly on the plate with pen and ink, or better, small printed numbers on tiny squares of paper—black numbers on a white ground or white numbers on a black ground, as suits the type of plate—may be glued on the plate. Such numbers may be had in sheets and cut up as needed. As neat, exact squares of small size are not easy to cut, a guide is a great help. Such a guide is supplied by the edge of a glass microscope-slide, the sheet or numbers and the slide being held together and the cutting done along the edge of the slide. The numbers are in sight during the cutting.

The best place for the number is directly under the center of the figure and not too close nor too far from it—about 3 mm. is good. It is well that this distance be uniform. Where figures are within rectangular blocks the numbers may be placed uniformly in the lower right-hand corners.

The size of the number used must be adjusted to the degree of reduction to be made in the engraving and also the kind of engraving—small numbers that would be clear in a zinc etching are apt to be blurred in half-tone. Over-large or over-conspicuous numbers are unsightly; very small numbers are hard to find and to read when found. Numbers to be about 2 millimeters in height in the engraving will be satisfactory for zinc etching, about 3 mm. for half-tone.

When printed numbers on small paper squares are to be glued on photographic paper, or indeed on any smooth paper, it will insure their staying on if the surface of the spot where each is to stand is scratched to roughen it.

A pair of tweezers is almost a necessity for handling the small squares of paper.

The background in plates intended for zinc etching. In these, as stated above, the figures must consist of a clean black design on a white background. The space between the figures is unimportant, for the engraver will remove from the cut everything but the black design.

The background in plates for half-tone engraving. In these the entire background, that is, the whole area within the borders of the plate, will show in the engraving and it must be of a sort that is inoffensive to the eye or it must be removed from the engraving by "routing"—a cutting away of the unwanted parts of the metal plate. The edge of a photographic print shows when pasted down, even though the background of the print is white; therefore, when prints are very roughly or irregularly cut out and assembled to make a plate, the result is unsightly unless all background is mechanically removed or routed. This routing adds much to the cost of the engraving, particularly where the engraver has to follow the complicated outlines of individual figures, and in the interest of economy it is desirable to reduce the need for it to a minimum or even eliminate it. Several methods are in current use for making a background in the original that will be acceptable in the engraving with little or no routing. These are as follows:

(1) Trim the individual figures exactly on their outlines and mount on a uniform background, preferably white though in some cases better in a gray or an even black. The figures may be numbered by hand or printed numbers glued on, using the appropriate color. This method is easy where the outlines are simple, but becomes difficult where the outlines are complex. A pure white background in the original will reproduce as a faint gray, the black background as a pure black.

(2) Mount the individual figures without regard to the background. Photograph the whole plate and "paint out" the background on the negative with red opaque or red dye, or use the red cellophane method. Make a print, which now shows the figures standing on a clear white background. Do all retouching of the figures on this print. Put the numbers on by hand-lettering; glued numbers are not suitable here. This print is the finished "copy" for the engraver. There is some loss of contrast in this process of copying photographs —the blacks are not usually as dense in the second photograph as in the original, and the whites are often not a pure color—hence it is best to use the first photos or the retouched photos and original drawings as engraver's copy whenever it is possible to do so.

(3) Proceed as in (2) to mount and photograph the plate. Make a print and blacken the background with lampblack, peach black, or Devoe showcard black. India ink can be used but has more sheen than the others named. Use white numbers, lettered on by hand or glued on. The blackened print is the finished "copy" for the engraver. If the original mounting is carefuully done, it is possible to achieve the same effect by blackening the background on the original instead of using a photographic copy of it. The loss in photographing is thus avoided.

(4) Trim each figure, with its individual background, to an appropriate rectangle. Mount the figures to make the plate, taking care to make the margins of the plate straight lines, that is, set the outer row of figures flush with the margin, and leaving spaces between the individual rectangles. The rectangles, or such parts of them as are not filled by natural background, may now be blackened, leaving the interspaces white. The margins of the rectangles must be parallel to the margins of the plate and the relative sizes of the interspaces adjusted for pleasing effect. The numbers may be placed in the interspaces or within the rectangles, particularly the latter if the interspaces are to be routed. It is a matter of taste as to whether the solid black background or the black rectangles presents the best appearance.

(5) If the backgrounds of the individual figures are all white—have been "painted out" individually on the negatives in the case of photographs or left white in the case of brush drawings or shaded pencil drawings—they may be trimmed rectangular and arranged as in (4). If this is neatly done the outlines of the white rectangles will not be particularly offensive in the engraving.

REVIEWS AND NEW PUBLICATIONS

B. BRASHAD, RECENT AND FOSSIL VIVIPARIDAE: A STUDY IN DISTRIBUTION, EVOLUTION AND PALAEOGEOGRAPHY. Memoirs of Indian Museum, Calcutta, Vol. 8 (1928), No. 4, pp. 153-251.

This paper reviews and to some extent revises the recent and fossil Viviparidae of the world. The author's evident unfamiliarity with some of the geological literature of North America has led to errors which should be corrected. Perhaps most conchologists will refuse to follow him in recognizing only three genera in the family, namely, *Viviparus* Montfort, *Cleopatra* Troschel, and *Larina* A. Adams, placing all the other usually-recognized genera, including the American *Campeloma*, *Lioplax*, *Tulotoma* and *Viviparus*, in the genus *Viviparus*, as subgenera. However, the differences separating them are slight and in paleontology we cannot know the anatomy except by inference, so their biological rank is really a matter of individual opinion. It may be well to let them rest as they are placed in the paper under consideration, particularly in dealing with fossil forms.

Brashad regards *Lioplacodes* Meek as a synonym of *Lioplax* Troschel, but by mistake cites the species as *L. nucalis* M. and H., instead of *L. veternus*. He rejects, probably with good reason, Cossmann's section *Paludotrochus*, proposed in 1921 to accommodate *Viviparus trochiformis* (M. and H.)

In the early days of western geology it was customary to assign all nonmarine beds to the Laramie formation, which has misled Brashad into assigning to the Laramie several species which do not belong there. Thus *Viviparus raynoldsanus* M. and H., to use the original spelling (not *reynoldsianus*, as Brashad spells it, following White), was described from and occurs chiefly in the Fort Union, Eocene, though some Laramie references may be correct. *V. leidyi* (M. and H.) is also a Fort Union species. *V. coueii* White is a Bear River species, either Lower Cretaceous or at the base of the Upper Cretaceous, several thousand feet below the Laramie.

Viviparus gilli M. and H. Brashad erroneously cites as *V. gillianus*, following White, 1883, (not White, 1877 or 1895). *V. subglobosus* (Emmons), described as *Paludina subglobosa* in 1858 (not *P. subglobosa* Say, 1825), should be known as *Viviparus? emmonsi* Henderson, 1920 (if, indeed, it is a *Viviparus* at all), unless Conrad was correct in making it a synonym of *Turbo glaber*, which is doubtful, and the generic position of *glaber* is also in doubt. *V. paludiformis* (Hall) is in error for *paludinaeformis*. He makes *V. formosa* Meek a distinct species, not a subspecies of *leidyi* M. and H., which is reasonable.

Concerning the "evolutionary series" of the well-known *Tulotoma thompsoni* White he says the "most primitive form with three well-developed spiral ridges on the various whorls is hardly distinguishable from *V. trochiformis* (M. and H.), which also is found with it and very probably represents its ancentral form." I have never found the two actually associated or even in the

[1]J. Henderson, *Nautilus* (1920), Vol. 33, p. 119.

same stratum, and, considering the fact that *trochiformis* seems to be confined to the Laramie Cretaceous and the Fort Union Eocene, while *T. thompsoni* extends down well into the Mesaverde Cretaceous, it is not likely that *trochiformis* is ancestral to *thompsoni*.

He mentions *Campeloma multistriatum* (M. and H.) as having "a wide distribution in the Laramie of the United States and Canada," but it was originally described from the Fort Union Eocene of North Dakota. He says that *C. macrospirum* Meek "was probably evolved from" *C. vetulum* (M. and H.), but *macrospirum* occurs in the Bear River beds of the Lower Cretaceous or basal Upper Cretaceous, while *vetulum* is found in the Judith and Hell Creek beds, hundreds of feet above the Bear River formation. He assigns *C. productum* White to the genus *Lioplax*, which White himself at one time suggested, but its position is too doubtful to make it worth while to transfer it. On the other hand, he makes no mention at all of *Goniobasis endlichi* White, from the Bear River formation, which is now generally considered a *Lioplax*. It may be incidentally mentioned that there are about nine other species of *Viviparus*, one *Lioplax* and one *Campeloma* from the Tertiary and Cretaceous of the United States and one *Viviparus* from Canada, not mentioned by him, but probably he did not intend to discuss the relationships of all the species.

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LORIS S. RUSSELL, UPPER CRETACEOUS AND LOWER TERTIARY GASTROPODA FROM ALBERTA. Trans. Royal Soc. Canada, (3), Vol. 23 (1929), pp. 81-90.

The terrestrial gastropod genus *Oreohelix* Pilsbry has been long known as the principal living snail genus of the Rocky Mountain and Great Basin region. Some years ago it was recognized as an Eocene and Miocene genus, in *O. grangeri* Cockerell and Henderson, *O. megarche* C. and H., *O. lecontei* (Stearns), *O. nacimientensis* (White) and *O. n. steini* Cockerell. Some of these were based upon specimens clearly showing the typical sculpture of the embryonic whorls. Russell's paper pushes the genus back into the Upper Cretaceous, by transferring to it the following species: *Patula obtusata* Whiteaves, *P. angulifera* Whiteaves, and *Helix (Pyramidula?) thurstoni* Russell.

Polygyra has been hitherto known from Eocene to Recent. Russell now describes as new, *Polygyra rutherfordi* and *Gonyodiscus sandersoni*, from the upper part of the Saunders formation, which is tentatively considered Upper Cretaceous. He describes as new, *Goniobasis tenuicarinata* var. *whiteavesi* and *Grangerella mcleodensis*, both from the St. Mary River, Cretaceous. The latter is called *Euconulus* in the text, but it is changed to *Grangerella* in a footnote. He has removed *Anachistoma parvulum* Whiteaves to *Paravitrea; Bulimus limneaformis*, or *Thaumastus limnaeiformis* Meek and Hayden, and variety *tenuis* Warren, to the genus *Campeloma;* and, following Wenz, refers *Bulimus* or *Columna haydeniana* Cockerell and *vermicula* Meek and Hayden to *Pseudocolumna*, in the Achatinidae.

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SOCIETY RECORDS AND ACTIVITIES

A FIELD MEETING OF THE SOCIETY IN OCTOBER

The Secretary, Dr. Gayle Scott, has been active in making preliminary plans for a field meeting of the Society of Economic Paleontologists and Mineralogists this fall, probably in the latter part of October. Previously these meetings have been held in the vicinity of Fort Worth, studying the Cretaceous and Pennsylvanian rocks of northern Texas; in western Missouri and eastern Kansas, studying the type sections of Pennsylvanian and lower Permian beds in the northern Mid-Continent region; and starting from Austin, visits to the Paleozoic and pre-Cambrian area of the Central Mineral Region of Texas and the Cretacous section along the Rio Grande in west Texas.

Tentative plans for the October meeting call for a gathering in southern Oklahoma, with the purpose of studying the fossiliferous Pennsylvanian rocks in the vicinity of Ada, on the north side of the Arbuckle Mountains, or possibly near Ardmore, on the south side of the mountains. There are many very interesting places especially attractive to the paleontologist near both of these cities and, if desired, it is easily possible to include in the itinerary any number of fossiliferous pre-Pennsylvanian outcrops.

Detailed plans are being made with the assistance of Dr. Chas. E. Decker, Professor of Paleontology, University of Oklahoma, Norman, Okla.

RAYMOND C. MOORE.

CHANGES IN PUBLICATION OF THE *JOURNAL OF PALEONTOLOGY*

Readers of the *Journal* will probably notice certain changes in appearance of this and following numbers of our publication, which are occasioned by transfer of printing to Tulsa, Oklahoma, in accordance with the desires of the Executive Committee of the Association. Previous issues of the *Journal* have maintained a high standard, and it is not so much with thought of improvement of mechanical work on the *Journal* that the change has been made as to centralize the publication activities of the Association, of which the Society is a division, and also to bring together business activities of the Association and Division which at present are scattered.

However, one improvement under this arrangement is the use of monotype instead of linotype. All good grade book-work and high class magazine publications are set in monotype, which, though more expensive, gives a superior result. Through combination with the *Bulletin of the American Association of Petroleum Geologists*, by increasing the gross printing which is done for the Association in the Tulsa plant, the costs of publishing the *Journal* are not increased. Besides contributing to easier, and, it is hoped, better handling of business matters for the Society through Association Headquarters at Tulsa,

any possible improvement of the *Journal*, even though small, will be a source of satisfaction to members of the Society.

Another change which is partly experimental at present is the use of plates that are reproduced by a photo-gelatin process. Such plates, if well made, are much superior to half-tone reproductions, and they are used in the highest grade of scientific illustrations. Through certain economies in paper and other manufacturing details and by reason of favorable quotations from the firm which is handling this work, it is possible to introduce this style of illustrations without added expense to the *Journal*. In fact there is a slightly lowered cost.

Officers of the Society, and especially the Editor, will welcome any suggestions or criticisms from members concerning material or method of handling the publication of the *Journal of Paleontology*. Such a publication is, of course, a joint enterprise, the development of which depends on united efforts of many individuals. Contributors to the *Journal* can assist a great deal by seeing that the form of their manuscript, including citations to the literature, arrangement of references in synonymies, and other details are in the form employed by the *Journal*.

EDITOR

AMONG PALEONTOLOGISTS

W. STORRS COLE is engaged during the summer in micropaleontologic work for the Sun Oil Company at Dallas, Texas.

FERDINAND CANU, distinguished French paleontologist who for many years has collaborated with R. S. BASSLER in study of fossil bryozoans, is spending part of this summer at the National Museum at Washington.

CLARK MILLISON is now located with the Shell Petroleum Corporation in the Mayo Building, Tulsa, Oklahoma. He was formerly located at the Wichita district office.

T. WAYLAND VAUGHAN is completing a paper on the larger foraminifera from the Eocene of Peru and is preparing one or more papers on Cretaceous larger foraminifera from Mississippi, Louisiana, Texas, Cuba, Yucatan, and Guatemala. Studies of the Tertiary larger foraminifera of the Gulf Coastal Plain, the Antilles, Mexico and Panama are under way.

G. LESLIE WHIPPLE, of the Scripps Institution of Oceanography, La Jolla, California, has completed papers on the larger foraminifera of the Eocene in Eua, Tonga Islands, the Miocene of Vitilevu, Fiji Islands, and Quaternary foraminifera from Vavau, Tonga Islands. A report is nearly finished on the larger foraminifera of the Island of Trinidad, based on collections by F. W. Penney, J. A. Bullbrook, H. G. Kugler, and all of the material gathered under auspices of Dr. August Tobler.

DONALD GRAVELL is preparing a general report on the larger foraminifera of Venezuela. Very extensive collections made by Dr. Kugler, M. N. Bramlette, Ruthven Pike, and others furnish an excellent basis for this study.

KATHLEEN TARVER, of the Pure Oil Company laboratory in Fort Worth, was married on July 5 to H. C. Pfannkuche, in Shreveport, Louisiana. Residence will be established in Fort Worth and Mrs. Pfannkuche will continue her work for the Pure Oil Company.

H. E. KOERNER has completed an annotated catalogue of fossil amphibians, birds, and mammals of Colorado, which is now available in manuscript form at the library of the University of Colorado.

O. P. HAY of the Carnegie Institution, Washington, and HAROLD J. COOK of the Colorado Museum of Natural History, Denver, are publishing in the Proceedings of the Colorado Museum an account of their studies of the past three years on fossil vertebrates collected near or in association with human artifacts at localities near Colorado, Texas, Frederick, Oklahoma, and Folsom, New Mexico. Mr. Cook has several other papers on fossil vertebrates awaiting publication.

CLINTON R. STAUFFER, of the University of Minnesota, has recently found an abundance of graptolites in the St. Lawrence formation of Upper Cambrian age at Afton, Minnesota. They have been turned over to Dr. Rudolf Ruedemann of Albany, New York, for study.

H. B. STENZEL of Texas Agricultural and Mechanical College is studying the Wellborne formation (Jackson) of Brazos County, Texas.

LAWRENCE F. ATHY is busy some 23 hours out of the 24 in geophysical work for the Continental Oil Company, Ponca City, Oklahoma.

JOSIAH BRIDGE is reported to have resigned his position as Professor of Geology at the Missouri School of Mines, Rolla, Missouri, to accept a place in paleontologic and stratigraphic work for the United States Geological Survey. He will probably be assigned work on lower Paleozoic formations which for many years have been the special field of study of Dr. E. O. Ulrich, recently retired under age regulations.

HORACE M. CORYELL of the Department of Geology, Columbia University, is engaged, as in recent previous summers, in micropaleontologic work for the Pure Oil Company at Tulsa.

DAVID M. DELO, who for the past year has been in charge of paleontologic work at Washington University, St. Louis, in place of COURTNEY WERNER on leave of absence, is engaged in geological work with CHESTER K. WENTWORTH for the War Department. They are studying dam sites and hydrologic problems on the Upper Missouri.

J. J. GALLOWAY of Columbia University is working on microfossils for the Gypsy Oil Company. He is located this summer at Ardmore, Oklahoma.

WALTER L. MOREMAN has completed residence requirements for the doctorate at the University of Kansas, and has accepted appointment as Assistant Professor of Geology, Texas Christian University, Fort Worth. During the summer he is continuing work on the Eagle Ford shale.

W. L. F. NUTTALL, who has been engaged in foraminiferal studies at Tampico, Mexico, is now at his home in Cambridge, England.

JOHN B. REESIDE, JR., spent a week with field parties in the Cretaceous area of western Kansas. Much of the remainder of the field season is devoted to conferences with parties of the United States Geological Survey in various parts of the Cretaceous of the western United States.

ALLEN C. TESTER of the Department of Geology, University of Iowa, is spending the summer in study of the Dakota sandstone of Kansas for the Kansas Geological Survey.

J. MARVIN WELLER of the State Geological Survey of Illinois has received a grant from the National Research Council for field expenses in studying cycles of sedimentation in the Lower Pennsylvanian of areas outside of Illinois. He has spent some time during the summer in Oklahoma, Missouri and Kansas.

CARL O. DUNBAR of Yale University has deviated from his usual summer field work by remaining at home in order to complete scientific writing which he has in progress.

BETTY KELLETT, paleontologist for the Amerada Petroleum Corporation, has been transferred from Tulsa to the Wichita office.

J. BROOKS KNIGHT is continuing his work for the doctorate at Yale University, New Haven, Connecticut.

WENDELL P. WOODRING has resigned his professorship at the California Institute of Technology, Pasadena, in order to resume work with the United States Geological Survey in Washington.

CHARLES E. DECKER, of the University of Oklahoma, is continuing field studies of Ordovician formations and fossils in southern Oklahoma. He is assisted by Rex McGehee.

JAMES WILLIAMS, of the University of Missouri, has been granted a year's leave of absence in order to permit research on the fauna of the Chouteau limestone, Mississippian, of Missouri. He will be located with Dr. George H. Girty, U. S. Geological Survey, Washington, D. C.

W. H. TWENHOFEL, of the University of Wisconsin, is teaching in the summer session of Leland Stanford, Jr., University.

LYNDON MORROW, of the University of Kansas, is collecting and studying Cretaceous fossils in Kansas for the State Geological Survey.

ROBERT ROTH and JOHN SKINNER, of the Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma, have completed papers dealing with stratigraphy of the early Pennsylvanian formations of the Mid-Continent and Rocky Mountain region, and on fusulinids, other formainifera and ostracodes from these rocks.

CHARLES RYNIKER, of the Gypsy Oil Company, Tulsa, Oklahoma, has recently studied an interesting core of dolomitic limestone at a depth of 3,400 feet in the Hege well, Sec. 13, T. 22 S., R. 2 W., Harvey county, Kansas. A sample of this sent to Raymond C. Moore yielded numerous fossils including, besides very abundant crinoidal remains, *Dictyonema* sp., *Technocrinus?* sp., *Atrypa reticularis*, *A. spinosa*, *Cyrtina hamiltonensis?*, *Meristella?* sp., *Fenestella* sp., A, *F.* sp. B, *Polypora* sp., *Spirifer* sp. aff. *S. curyteines*, *S.* sp. cf. *S. varicosa*, *Whitfieldella?* sp., and *Nucleospira ventricosa?*. This assemblage points to a Devonian age, though absence of abundant well defined Spirifers and the dolomitic, porous character of the rock suggest Silurian.

A. N. SAYRE, now a member of the U. S. Geological Survey, has completed a fairly large paper on the fauna of the Drum limestone (Kansas City group, Pennsylvanian) of Kansas and western Missouri. It is being published by the University of Kansas. The large number of very beautifully preserved fossils, including especially gastropods and pelecypods, makes this fauna unusually interesting.

DON GOULD, of the University of Iowa, is completing a faunal study of the Fort Riley limestone of Kansas and northern Oklahoma.

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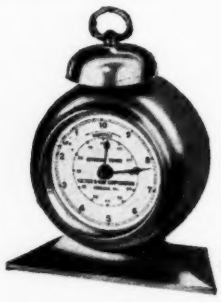

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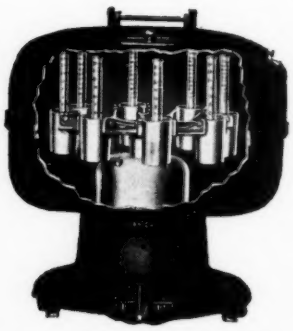

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